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1897.

NOTES ON THE NATURAL HISTORY OF THE WILMINGTON REGION.

H. V. WILSON.

A brief collecting trip to the vicinity of Wilmington, N. C., made about the middle of April, greatly impressed me with the natural history advantages of the region. I publish these few notes in the hope that they may be of service to other naturalists who think of visiting the Southern coast.

In Wilmington itself no one can fail to notice the admirable shade tree, the laurel oak (*Quercus laurifolia* Michx.), so common along the streets. This tree in Wilmington passes under the name of water oak; in South Carolina it is known as the Darlington oak. Its straight bole, symmetrical top and moderate size give it an elegance of shape well suited to city streets, and the impression of finish is heightened by the glossy aspect of the foliage.

From the city there runs a most excellent road, eight miles long, to Wrightsville, a settlement on the coast. The road is a well kept shell road, smooth, hard, and good for bicycling. Scrub oaks, elms, long-leaf pines and cypresses edge it, and near the sound the full green heads of the live oaks are seen on all sides. In the open

meadow-like places (savannahs) to the right and left of the road there grow in great abundance insectivorous plants, the most interesting members, to the general biologist at least, of that rich Wilmington flora made known through the labors of Curtis, Wood and other systematic botanists. The yellow-flowered pitcher plant, *Sarracenia flava*, dots the savannahs in all directions; its great flower (four inches wide) upheld by a scape one to two feet, making it a conspicuous object. The fly-trap, *Dionæa*, and sun-dew, *Drosera*, neither in flower at the time of my visit, are scattered thickly about. Intermingled with these are a blue and yellow species of butterwort, *Pinguicula*, their bright flowers standing out clearly against the (at this time) brownish savannah and often leading one to patches of *Dionæa* and *Drosera*, which otherwise would have been passed by unnoticed. These five insectivorous plants may sometimes be found growing together in a little patch of ground, scarcely larger than a square foot.

The topography of the Wrightsville district is that characteristic of the Carolina coast, and in a less degree of the Southern coast in general. A sound separates the mainland from a seaward strip of land, known as the 'banks.' Wrightsville, largely made up of houses occupied only during the summer, is on the mainland. Opposite it, on the banks, is a newer summer settlement. Between the two, the sound is crossed by a railroad trestle, the piles of which afford good collecting.

The sound something less than two miles wide, is divided into a narrow outer portion, adjoining the banks and known as the banks channel, and a wider inner portion, studded with sandy-mud shoals. The banks channel is a narrow but pretty boating ground, opening out to sea through two inlets, one recently made in a heavy storm. Along the inner edge of the channel lie some islands, the 'hammocks,' wooded with live oaks, about

which jackdaws (*Quiscalus major*) were flying. This bird is said to spend the winter here.

At high water one can sail over many of the shoals of the inner part of the sound, but at low water the course from the mainland to the banks channel is a meandering one. The shoals are alive with worms, *Arenicola*, *Diopatra*, *Clymenella* and other annelids, along with the great *Balanoglossus*, were dug up in quick succession. The reddish egg masses of *Arenicola* lay about in abundance on the flats. The low water collecting in the shoal part of the sound is very easy. Pushing along in a skiff through the shallow channels between the flats, one finds starfish (*Asterias*), the red and white sea-urchins (*Arbacia* and *Toxopneustes*), abundant crabs and other common bottom forms. Scattered about over the bottom in great numbers is the interesting anemone, *Cerianthus americanus*. The tubes that were dug up were something over a foot in length; they contained animals, which of course had greatly contracted, about six inches long. This distinctively Southern actinia, originally found on the South Carolina coast by Professor Louis Agassiz (Verrill, Revission of the Polypi of E. Coast of U. S., p. 32. Mem. Boston Soc. Nat. Hist., Vol. I.), has been observed by Mr. Wm. Stimpson and Professor McMurrich at Beaufort, N. C., where I have seen it myself. It is, however, far more abundant at Wrightsville, and any one wishing to work out the life-history of this remarkable form could find no better locality than the latter place. I may add that the reproductive organs of the specimens I collected were very small. The breeding season probably comes on later.

Just before high water I towed in the neighborhbod of the old inlet. As I had anticipated from previous experiences in Beaufort harbor at this time of year, not much of interest was in the water. Small hydromedusæ, crustacean larvæ, abundant *Sagittas*, make up the tow stuff. Later in the year, doubtless as at Beaufort, the towing is

excellent. I am told that abundant large jelly-fish and Portuguese men-of-war make their appearance in August and September.

The sea-beach has a very gentle slope, and judging in part from specimens sent me by Mr. Chas. M. Whitlock, of Wilmington, many things of interest are to be had just beyond the line of breakers, where the sea is frequently calm enough to permit collecting. In the main the Wrightsville fauna is evidently very similar to that of Beaufort (see the lists in Studies of Biol. Lab. Johns Hopkins Univ., Vol. IV., No. 2, and the list of annelids by Professor Andrews, Proc. U. S. Nat. Mus. Vol. XIV,, No. 852). I may add that some of the local collectors would recognize, from a description, many of the striking forms, such as *Chætopterus*, *Chalina arbuscula*, *Leptogorgia virgulata*, all of which may be had here.[1]

[1] From *Science N. S.*, Vol. VI. No. 135. July 30, 1897.

(Contributions to the Chemistry of Zirconium. No. 6.)

THE OXALATES OF ZIRCONIUM.

BY F. P. VENABLE AND CHARLES BASKERVILLE.

The text-books of chemistry make either very little or no reference to the oxalates of zirconium. Beyond an occasional reference to the oxalate or basic oxalate gotten by precipitating oxalic acid or an oxalate, we can find little mention of these compounds. Behrens, in his microchemical work, speaks of an oxalate prepared as colorless pyramids by precipitating a solution of zirconium sulphate with potassium binoxalate, but no analyses are given, and the crystals could scarcely have been the pure oxalate. Paykull[1] speaks of double oxalates being prepared with

the alkaline oxalates (1:2) and of his failure to prepare the neutral oxalate. His methods, and indeed full results, are unknown to us, as we did not have access to the original paper.

We may summarize the work which follows in the succeeding pages by saying that we found it possible to prepare the basic oxalates by precipitation. This was usually in the form of $Zr(C_2O_4)_2$, $Zr(OH)_4$, though other ratios were gotten. The neutral oxalate we did not succeed in preparing, but instead the tendency seems to be toward the formation of the acid oxalate, $Zr(C_2O_4)_2.H_2C_2O_4.8H_2O$. This tendency toward the formation of acid salts was shown also in the double oxalates. Two of these were prepared. For sodium, $Zr(C_2O_4)_2,3Na_2C_2O_4.H_2C_2O_4.5H_2O$, and for potassium the salt $[Zr(C_2O_4)_2]_2.(K_2C_2O_4)_2.H_2C_2O_4.8H_2O$. The oxalate with amonium as a constituent was not so easy of preparation in a pure state. The compound secured was $Zr(C_2O_4)_2.2(NH_4)_2C_2O_4$. The experiments and analyses are given in detail.

ZIRCONIUM OXALATES.

The Oxalate Gotten by Precipitation.—On the addition of a saturated solution of oxalic acid to a slightly acid solution of zirconium chloride until no further precipitation occurred, a gelatinuous precipitate formed which had very nearly the composition $Zr(C_2O_4)_2.2Zr(OH)_4$. Analysis I gave Zr, 46.39, and C_2O_4, 30.89, instead of the theoretical 46.40 and 30.93 respectively. The filtrate from this was turbid, and on standing yielded another precipitate which had nearly the composition $2Zr(C_2O_4)_2.3Zr(OH)_4$.

The basic oxalates are very difficultly soluble in acids, and of extremely fine subdivision, settling slowly and passing through even the best filters. It does not seem probable that they could be secured of very constant com-

[1] Ofv. af. Vet. At. Förhandl. ref. in *Ber. d. chem. Ges.*, 12, 1719.

position. Probably basic oxalates with many different ratios between the oxalate and the hydroxide might be secured. On drying at 100°, or even a little lower, the oxalic acid is gradually volatilized and lost. This is true of all the oxalates and double oxalates prepared so that the only mode of drying these preparations was between filter paper.

The Acid Oxalate Prepared by Crystallization.—In preparing this oxalate, zirconium hydroxide was dissolved in oxalic acid. The hydroxide is quite soluble in oxalic acid, and a concentrated solution is readily obtained. A considerable excess of the acid is required to hold the oxalate thus formed in solution. If this solution be acidified by means of hydrochloric acid a very fine precipitate is obtained settling very slowly, easily passing through the best filter papers and insoluble even in a considerable excess of the acid, but soluble in concentrated sulphuric acid. This precipitate was not analyzed, nor were the exact conditions of its formation determined, as its examination did not promise results of sufficient importance to justify overcoming the difficulties in the way.

On evaporating the acid solution of the oxalate the excess of oxalic acid first crystallized out. In the various preparations made, the first one or two crops of long crystals were found to be nearly pure oxalic acid, and were rejected. Th n the form of the crystals changed to small granular or prismatic masses, and with each succeeding crop of crystals the percentage of zirconium increased, reaching speedily an approximately constant ratio. No difference in the form of the crystals in these different crops could be detected on superficial examination, and hence it was impossible to distinguish between the zirconium oxalate and the oxalic acid almost free of zirconium, except by analysis. In no case was the normal oxalate secured. The analyses showed a tendency toward the formation of an acid oxalate and to mixtures of this with the normal oxalate. These mixtures were gotten in the later crys-

tallizations, but the last crystallization, when nearly the whole would solidify into a crystalline mass, showed decreased percentages of zirconium. It is possible that larger amounts than we had at our disposal would enable one to so fraction the crystalizations as to secure a pure oxalate. It is, however questionable whether the normal oxalate can exist in solution without admixture with some oxalic acid.

Four series of crystallizations were made, and in two cases fairly abundant crops of crystals corresponding to the acid oxalate were obtained. In each series enough of the zirconium hydroxide was taken to form about twenty grams of the oxalate.

	First series. Sixth faaction.	Second series. Fifth fraction.	
	II.	III.	$Zr(C_2O_4)_2.H_2C_2O_4$.
Zr	25.44	25.28	25.53
C_2O_4	74.55	74.72	74.47

These are calculated upon the water-free basis. The crystals contained 29.34 and 29.27 per cent. of water respectively, where the salt $Zr(C_2O_4)_2.H_2C_2O_4.8H_2O$ contains 28.90 per cent. Other crops of crystals contained percentages of zirconium not varying greatly from those given above as 28.14, 27.62, 24.9, 23.83. The percentage of zirconium in the normal oxalate is 33.96.

ZIRCONIUM SODIUM OXALATE.

The addition of sodium oxalate to a slightly acid solution of zirconium chloride gives a gelatinous white precipitate. Most of this dissolves in an excess of the oxalate. The undissolved portion settles to the bottom, and after prolonged standing, a second layer of a more powdery appearance forms. This can also be gotten by concentration of the filtrate from the first precipitate. Analysis showed that the first gelatinous precipitate was chiefly $Zr(OH)_4$. The second precipitate was a double oxalate of zirconium and sodium, but was either of incon-

stant composition (varying ratios of sodium to the zirconium), or was decomposed by the washing.

The analyses, calculated on a dry basis, gave:

	IV.	V.	VI.
Zr	53.12	46.86	41.98
Na	9.16	4.10	1.07
C_2O_2	38.06	39.64	42.95

If the solution made with the excess of the sodium oxalate was diluted considerably with water, a gelatinous precipitate was formed, very fine and insoluble. Precipitates were also formed by the addition of hydrochloric acid. This mode of forming the double oxalate was abandoned, and the following method was adopted with greater success. Zirconium hydroxide was dissolved in an excess of oxalic acid, and to this a concentrated solution of sodium hydroxide was added, bringing it nearly to neutralization. When the solution was concentrated an abundant crop of crystals was obtained on cooling, a good deal of heat being evolved in the mixing. Further evaporation yielded other crops of crystals. These were washed, dried between filter paper and analyzed. The results are given in the following table:

	VII.	VIII.	IX.	Calculated.
Na	18.14	17.46	17.75	18.19
Zr	12.59	12.66	12.78	11.93
C_2O_4	69.27	66.89	69.47	69.88

These results show a somewhat wide variation from those calculated. This probably arises from the fact that the fractions were not composed of the crystals of a single kind of oxalate, but had other oxalates mixed with them in small amounts. Examined under a magnifying glass they seemed to be homogeneous, but the different crops could not be distinguished from one another. They were all small, hard prismatic crystals, somewhat difficultly soluble in water. One set of crystals, the analysis of which is reported under VII in the above table, was

redissolved in water and recrystallized. On analysis it yielded the following results:

	VII.	IX.
Na	18.14	18.19
Zr	12.59	12.71
C_2O_4	69.27	69.10

These were calculated upon a water-free basis. The crystals from the various crops mentioned above did not contain a very constant amount of water, but ranged from 9.13 to 11.06. The calculated amount of water in $Zr(C_2O_4)_2.3Na_2C_2O_4.5H_2O$ is 10.62. It would seem, therefore, that the tendency, when this method of formation is adopted, is toward the formation of crystals containing free oxalic acid and with the sodium and zirconium oxalates bearing a ratio of three to one.

ZIRCONIUM POTASSIUM OXALATE

The curdy precipitate gotten by precipitating zirconium chloride with normal potassium oxalate is insoluble in an excess of either of the substances. The precipitate first obtained is an impure zirconium hydroxide, containing only small amounts of oxalic acid. The supernatant liquid on concentration yields needle-like crystals of potassium oxalate, carrying only traces of zirconium. After the separation of a good deal of this potassium oxalate, further concentration yielded a gelatinous substance having the composition (XII): Zr, 39.34; K, 5.06; C_2O_4, 43.05; which seems to be a basic zirconium oxalate, mixed or united with a small proportion of potassium oxalate. If the potassium be calculated as potassium oxalate and subtracted, the composition of the remainder would be approximately $Zr(OH)_4.\ Zr(C_2O_4)_2$.

On adding potassium binoxalate to a solution of zirconium chloride a white curdy precipitate was obtained which was not completely soluble in excess of the binoxalate. The somewhat turbid solution was filtered and evaporated. Large crystals resembling those of oxalic acid formed. These were separated, and on analysis proved

to be oxalic acid. At the same time a number of small crystals were formed, which were mechanically separated, washed and dried. These were analyzed and are reported under XIII. A further crop was gotten from the mother liquor, and the analysis is given under XIV.

	XIII.	XIV.
Zr	19.59	17.99
K	16.18	13.91
C_2O_4	64.23	68.09

The curdy precipitate, which first formed, was also examined and found to have the composition $Zr(C_2O_4)_2.2Zr(OH)_4$.

The addition of a solution of potassium tetroxalate to zirconium chloride gave a gelatinous precipitate of zirconium oxalate (basic), carrying a little potassium oxalate. Subtracting the potassium oxalate, the percentages (XVI) Zr, 39.09 and C_2O_4, 38.63 are left, which are not very different from the figures gotten for the precipitate from potassium oxalate (neutral).

This curdy gelatinous precipitate was dissolved in excess of tetroxalate and the solution placed over sulphuric acid to crystallize, and yielded crystals having the composition (XVII): Zr, 20.85; K, 16.72; and C_2O_4, 62.31. As will be seen, these are not far from the 1:2 zirconium potassium oxalate, with excess of oxalic acid.

When potassium hydroxide was added to a solution of zirconium oxalate in oxalic acid until nearly neutral and then set aside for crystallization, various crops of crystals were gotten, as in the case of the double sodium oxalates. These crops of crystals were similar in appearance to the sodium crystals. They were analyzed and showed fairly constant composition.

	XVIII.	XIX.	XX.	XXI.	$(Zr(C_2O_4)_2)_2.(K_2C_2O_4)_2.H_2C_2O_4.$
Zr	18.08	19.25	19.83	18.47	18.95
K	16.41	16.35	14.84	14.46	16.34
C_2O_4	66.51	64.40	65.33	67.07	64.71

The three previous analyses may also be referred to

here as having approximately the same composition. See analyses XIII, XIV, XVII. These are calculated as water-free. In the analyses XVIII and XIX the percentages of water were 12.99 and 12.38. These would correspond to the formula $(Zr(C_2O_4)_2)_2.(K_2C_2O_4)_2.H_2C_2O_4.8H_2O$. In this case, as in the zirconium oxalates and the sodium oxalates, the crystals seem to form only along with free oxalic acid, giving acid salts.

ZIRCONIUM AMMONIUM OXALATES.

The addition of a solution of ammonium oxalate to the slightly acid solution of zirconium chloride gave a heavy gelatinous precipitate which was soluble in excess of ammonium oxalate and proved to be zirconium hydroxide with more or less zirconium oxalate and small amounts of ammonia. The filtrate from this precipitate was evaporated slowly and a fine crystalline powder obtained. This contained (XXII) Zr, 42.17 per cent. and C_2O_4, 39.86 per cent. This is in fair agreement with $Zr,(C_2O_3)_2.Zr(OH)_4$. When ammonium oxalate is added until the first gelatinous precipitate is redissolved and then evaporated to crystallization, different crops of crystals can be gotten containing various amounts of ammonia. These did not seem to have any regular composition in our experiments and were looked upon as basic zirconium oxalates with varying amounts of ammonium oxalate present. Thus for one of these the figures (XVIII) Zr, 31.48; NH_2, 7.14; and C_2O_4, 61.38 were gotten.

Abandoning this method and using the one adopted in the cases of the sodium and potassium double oxalates, a more favorable result was optained. Zirconium hydroxide was dissolved in excess of oxalic acid and then this was nearly neutralized by means of ammonium hydroxide. Analyses of these crops of crystals follow:

	XXIV.	XXV.	$Zr.(C_2O_4)_2.2(NH_4)_2C_2O_4$.
Zr	16.55	16.66	17.58
NH_3	14.46	13.35	13.28
C_2O_4	69.99	69.99	68.94

While these do not show that the crystals had been thoroughly purified, the restlts indicate that the composition is one zirconium oxalate to two ammonium oxalate. On recrystallizing one of these crops of crystals, zirconium hydroxide was observed to separate when the solution was heated (to evaporate to crystallization), and the crystals which were obtained consisted of ammonium oxalate alone.

In general it may be stated that the zirconium oxalate fails to show any decided tendency to enter into clearly defined combinations with the alkaline oxalates, exhibiting rather a power of crystallizing along with them in mixtures of any proportions. It can be said at best that under the conditions of our experiments certain ratios seem to be preferred, and appeared more presistently. In all cases the crystals formed from oxalic acid solutions, and this free oxalic acid crystallized with them, giving acid oxalates.

THE HALOGEN SALTS OF ZIRCONIUM.

F. P. VENABLE AND CHARLES BASKERVILLE.

I. DECOMPOSITION OF THE ZIRCONS.

It may be well to give in detail the method (Jour. An. and Ap. Chem. 1891.551) as modified by an experience of several years. The zircons are ground in an iron mortar so as to pass a 90 mesh sieve. The proportions used in a fusion are 150 grams zircons, 400 grams sodium hydroxide 40 grams sodium fluoride. The sodium hydroxide and fluoride are fused in a nickel crucible (400 cc) then heated for fifteen or twenty minutes with the water blast

The zircons are introduced in portions of five or six grams. If the temperature is high enough there is a rapid evolution of bubbles of gas. It must be stirred to prevent foaming over (the stirrer being a strip of nickel fastened to a glass rod.) After the introduction of three-fourths of the zircon the temperature should be increased by adding other lamps as the mass becomes pasty and sluggish towards the close of the reaction, making the escape of bubbles somewhat explosive. The success of the operation depends on the high temperature, especially at the close. With a lower temperature much will be left unacted upon. After the introduction of all the zircon the mass should be heated and stirred until no more bubbles escape. This stirring can only be imperfectly carried out towards the close. The mass should then be immediately removed by means of a nickel spatula and the lumpy pieces allowed to cool on crucible tops or sheets of nickel. The crucible should be scraped as clean as possible before cooling. It is best then to quench it with water before the adhering pieces of the melted mass cool, and crack the crucible in contracting. A number of crucibles crack during the fusion. If they escape this they almost infallibly crack in the cooling unless cooled down filled to the brim with water. Of course due care must be taken in introducing the water. It can be safely blown in from a distance with a wash bottle. As there is much spitting of melted caustic soda during the fusion the hands should be gloved and the handle of the stirrer should be long enough to secure the face and eyes from danger.

The lumps, while still hot, are removed from the nickel sheet and placed in water in a casserole (1 litre capacity). After a few minutes the water becomes muddy on agitation. Pour off this water with the suspended particles into a large settling jar. Refill the casserole, heat to boiling, stir and pour off again, thus removing gradually the finer masses. This is the best way of disintegrating

and washing the mass. The particles settle best from hot water. After a while they settle slowly. It is best to use two or three settling jars, pouring off from the first to the others before a second washing is added from the casserole. Nearly all settles in the first jar and that which settles more slowly may be allow to take its time in the other jars. After a while the disintegration may be helped by breaking with a glass rod or rubbing with a pestle. Five or six gallons of water should be used in washing as this removes the sodium silicate and it is far easier and better to get rid of it in this way than to be worried by its presence later on. Of course it is not entirely removed and some little of the zirconate is also lost.

After washing the sodium zirconate must be decomposed by the addition of hydrochloric acid. Strong acid is used and it is boiled with the zirconate in the casserole used for washing. Usually all dissolves up except a few grams of undecomposed zircon. It is not necessary to filter the solution. It may be immediately transferred to a large evaporating dish and carried down to dryness, first over the naked flame and then, as silica etc., begin to separate out, on the sandbath. It is necessary to watch the temperature of the latter and to stir the mass up occasionally to prevent overheating but a great deal of time may thus be saved. It is usually possible to begin a fusion in the morning and have the hydrochloric acid solution of it ready for evaporation before the day's work is over.

If the washing was well done the amount of silica separating is not large. Hydrochloric acid is added to the dried mass, then water and it is filtered. The clear filtrate is again evaporated to dryness to remove the last traces of silica. We have uniformly adopted this precaution but seldom found any silica separated by the last evaporation. After this second evaporation and filtration the solution is ready for the separation of the iron.

The larger portion of the iron may be separated by the use of sulphur dioxide. The impure zirconium chloride is made up into a moderately dilute solution in a large jar. This is nearly neutralized with ammonia and sulphur dioxide is passed through. The zirconium is precipitated out as a basic sulphite. This is filtered away from the solution containing most of the iron. In most cases it is advisable to dissolve again in hydrochloric acid and precipitate once more with sulphur dioxide. The filtrate containing the iron also contains much of the zirconium. A good deal of this is precipitated on boiling. The filtrate from this is then evaporated to a small bulk and a good deal of the iron will crystallize out as the double chloride of iron and ammonium in deep red crystals. The concentrated filtrates from several fusions, thus partly freed from iron, may be again treated with sulphur dioxide and the zirconium recovered.

The sulphite after draining in large funnels is dissolved in hydrochloric acid and boiled until all sulphur dioxide is driven off. It is then precipitated as hydroxide by means of ammonium hydroxide and well washed. This hydroxide is drained upon filters and dissolved in the least amount of concentrated hydrochloric acid. The remaining impurities are gotton rid of by repeated crystallizations from strong hydrochloric acid. This must be managed with some care as it is quite easy to form an oxychloride insoluble in the strong acid, for instance by the addition of strong acid to a somewhat concentrated aqueous solution. In evaporating the hydrochloric acid solution to crystallization it is therefore necessary to add concentrated acid from time to time as the watery acid evaporates so that the first crystallization shall be from strong acid. After that there is little trouble in subsequent crystallizations from strong acid. The crystallizations are best made from a casserole and one hundred grams or more of chloride may be crystallized at a time. Generally twelve or fifteen crystallizations will

suffice. There will be little loss of zirconium if just enough acid is used each time to bring the soluble chloride into solution (some little insoluble chloride is nearly always present.) The acid poured off each time from the crystals may be saved and evaporated to recover the zirconium or used in the decomposition of other portions of zircons.

II. ZIRCONIUM CHLORIDES.

Large number of compounds of zirconium with chlorine or chlorine and oxygen have been described and these compounds have been the subject of much investigation. The object in many cases has been to secure a zirconium chloride of definite composition which would prove a valuable compound for determining the atomic weight of the element. There are several difficulties in the way of securing such a compound.

1. The tendency to form basic chlorides.
2. The ease with which hydrochloric acid is lost through the action of heat and of dehydrating agents.
3. The presence of free hydrochloric acid.
4. The deliquescent nature of the chlorides.

It is particularly desirable that the conditions under which a definite chloride can be formed should be discovered, as zirconium seems to yield no very satisfactory compounds for the determination of the atomic weight. There have been many efforts at finding out these exact conditions.

Most text-books state that anhydrous, pure zirconium tetrachloride can be prepared by passing dry chlorine over a mixture of charcoal and zirconia heated to a high temperature. Hermann used this sublimed zirconium chloride for the determination of the atomic weight. As Clarke says, however, little confidence can be placed in his results. Bailey (Chem. News., 60, 17.) has recorded that even with great care to avoid the presence of moisture he was unable to prevent the formation of oxychlo-

rides. He also says that in no case was it found possible to prepare the chloride free from iron and silica. The necessity for the presence of these in the materials used or in the resulting compound is not very apparent. We have as yet had no opportunity of repeating his experiments.

This tetrachloride has also been prepared by passing dry chlorine over zirconium or over zirconia and charcoal.

Troost and Hautefeuille [Compt. rend. LXXV., 1889.] have prepared it by the action of silicon chloride upon zirconia. Smith and Harris [Am. Chem. Soc. 1895. 654] succeeded in preparing this same chloride by heating zirconia with phosphorus pentachloride.

The chlorides most commonly worked with, have been those formed by the solution of the hydroxide in hydrochloric acid, followed by precipitation or crystallization from concentrated hydrochloric acid or from water.

Berzelius attempted to remove the excess of hydrochloric acid by heating the salt to 60°C. but was not able to obtain a definite compound.

Two analyses gave

ZrO^2	0.332	0.485
AgCl	0.661	1.096

The silver chloride should be about two and one-third times as much as the oxide.

Paykull dried the salt between filter paper and found the composition of the crystals to be $ZrOCl_2.8H_2O$. According to Melliss (Zeitschr. f. Chem. [2], VI. 196) this salt crystallizes with $4\frac{1}{2}H_2O$ instead of $8H_2O$. The amorphous form is precipitated by pouring the aqueous solution into strong hydrochloric acid. This is insoluble in boiling concentrated acid but easily soluble in water. Paykull (Ber. VI. 1467) assigns to this the formula $2ZrOCl_2.13H_2O$.

Endemann has described basic or oxychlorides $Zr_3O_4Cl_4$, ZrOClOH, and $Zr_8O_8Cl_7(OH)_9$; Troost and Hautefeuille have described others, $Zr_2O_3Cl_2$ and Zr_2OCl_6. In fact water is so easily taken up and hydrochloric acid lost

that a large number of such indefinite compounds might be prepared by slightly varying the conditions.

Nylander (Bidrag till kännedomen om Zirkonjord Inaug. Diss. Lund 1864.) made a series of attempts at dehydrating the chloride. He prepared the chloride by dissolving the hydroxide in hydrochloric acid and evaporating to crystallization. The salt formed white needles, easily soluble in water. They were washed with alcohol and for analyses I and II were pressed between filter paper; III and IV were dried over sulphuric acid. The results were as follows:

	I.	II.	III.	IV.
Zr	27.56	25.69	30.11	31.78
Cl	21.58	21.58	23.06	23.80
Loss(H_2O)	50.86	52.78	46.83	44.12

or calculated on a dry basis:

Zr	56.08	54.41	56.63	57.18
Cl	43.02	45.59	43.37	42.82

Again preparations were made as before. I was dried between filter paper, II over sulphuric acid, III was pressed between filter paper and then dried over sulphuric acid, IV was dried a long time over sulphuric acid. The analyses gave the following:

	I.	II.	III.	IV.
Zr	28.52	34.91	37.78	35.69
Cl	21.93	26.09	25.87	21.74
Loss	49.55	39.10	36.35	42.57

or calculated on a dry basis:

Zr	56.93	57.23	59.34	62.14
Cl	43.07	42.77	40.66	37.86

Lastly he allowed a solution of the chloride to evaporate over sulphuric acid washed the crystals obtained with alcohol and pressed them between filter paper. Analyses gave:

Zr	27.94	28.74
Cl	27.32	26.67
Loss	44.74	42.62

or calculated on a dry basis:

Found		Theory.	
Zr	50.56	50.04	Zr 38.50
Cl	49.44	49.96	Cl_4 61.50

Nylander's description of this salt is correct. Very large handsome crystals can be secured on evaporating an aqueous solution of the chloride prepared by dissolving the hydroxide in hydrochloric acid. If this evaporation is too rapid gelatinous masses separate out, re-dissolving on stirring. There is a considerable loss of hydrochloric acid during this evaporation. The best crystals may be obtained by evaporation over sulphuric acid. These crystals easily dry on porous plates or on filter paper. There is no necessity for the elaborate methods of drying adopted by Nylander. There is however a constant though slight loss of hydrochloric acid. Nylander's analyses (marked I) agree very closely with one made by us.

Zr	28.05
Cl	21.59
Loss	50.46

There is then manifestly a definite compound obtained in this way. It is unquestionably an oxychloride and the loss (50.46 per cent.) represents both water and combined hydroxyl or oxygen. At ordinary temperatures there is a continuous loss from day to day which makes it impossible to get a fixed initial weight. This loss is shown by the following weighings.

Date	Oct. 9.	Oct. 11.	Oct. 12.	Oct. 13.	Oct. 15.	Oct. 18.
Weighings	1.2806	1.2796	1.2792	1.2787	1.2779	1.2758

By heating to 135°-140° for six hours a large amount of chlorine is driven off and yet not all of the water. The mass left is insoluble. Heated to 100° under a stream of hydrogen chloride the weight was constant and the loss corresponded to 26.84 per cent. of the original weight. The residue is entirely soluble in water. While these data are not altogether sufficient it will be seen that they correspond fairly accurately with the formula $ZrOCl_2 8H_2O$. Five molecules of water are lost at 100° and the compound left is $ZrOCl_2.3H_2O$. The first formula is the formula assigned by Paykull and confirms his results as against those of Melliss. The formula gotten by Herrmann, $ZrOCl_2.9H_2O$ was manifestly obtained from imperfectly dried crystals.

Bailey repeatedly crystallized the chloride from hydrochloric acid, washed it with hydrochloric acid and then removed the free acid.

(1) By washing with a mixture of one part alcohol and ten parts of ether.

(2) By gently heating the salt.

(3) By exposing the finely divided salt at ordinary temperatures in a vacuous desiccator over potash until no hydrochloric acid appeared when air was passed over it.

The analysis was performed by dissolving the salt in water and precipitating the zirconia with ammonia, then acidulating with nitric acid and precipitating the chlorine by means of silver nitrate. By method (2) a constant and progressive diminution of chlorine was observed. Therefore no analyses were made. For the other methods he gives the results of the analyses by a statement of the relation of ZrO_2 to AgCl.

	ZrO_2 : AgCl
Berzelius determination	1 : 1.991
" "	1 : 2.260
Bailey's method 1	1 : 2.206
" " "	1 : 2.179
" " "	1 : 2.226
" " "	1 : 2.260
" " 2	1 : 2.264
" " " without washing	1 : 2.245
" " "	1 : 2.309
" " "	1 : 2.285
$ZrOCl_2$	1 : 2.350

In all of these the drying has gone too far and some of the chlorine has been lost or the crystals still retained hygroscopic moisture. This salt, as will be seen later on, is not $ZrOCl_2$ but $ZrOCl_2.3H_2O$ and the true ratio is $ZrO_2 : AgCl :: 1 : 2.327$.

Hermann (Watts' Dict., 5, 1080.) states that the hydrated chloride, gotten in crystals on evaporating its aqueous solution, becomes opaque at 50° C., giving off part of the water and half of the hydrochloric acid and leaving a basic chloride or oxychloride, $ZrCl_4.ZrO_2.18H_2O$ or $ZrOCl_2.9H_2O$. The same compound is obtained in stellate groups of

white silky prisms on evaporating a solution of the chloride. These crystals when heated become white and turbid and are converted into the anhydrous dioxychloride, $ZrCl_4.2ZrO_2$.

Linnemann (Chem. News., LII, 224.) maintains that crystallization from hydrochloric acid (sp. gr. 1.17) and treatment with alcohol and ether gives a fine, crystalline, snow white, silky body, leaving fifty per cent. of its weight on ignition and therefore very nearly pure $ZrCl_4$ which should leave 52.5 per cent. He claims that this is "chiefly a neutral, not a basic compound."

Our own experiments on the dehydration of the salt obtained by crystallization from water extended over two years, as opportunity was afforded. Several series of experiments were undertaken, some along the lines attempted by others, and others by methods not tried before. In all the purified chloride obtained by repeated crystallization from hydrochloric acid was used, the salt being still wet with the excess of the acid. There was no attempt at drying this between filter paper.

In the first experiment this chloride was washed once with water and then put in a desiccator and dried over calcium chloride (porous desiccated). It remained in the desiccator about seven months. Even after this lapse of time it still continued to show a slight loss in weight. It yielded on analysis 48.84 per cent. ZrO_2.

Another portion was placed in a jar over solid lumps of sodium hydroxide. After six weeks the loss was very slight. Careful ignition left a residue of ZrO_2 equivalent to 42.99 per cent. of the original weight. There was found to be 24.44 per cent. of chlorine present.

Again a portion was placed over calcium chloride and dry air was drawn over it at the rate of about fifty liters in the twenty-four hours for six months. After the first two months it was examined weekly by the interposition of a flask containing silver nitrate to see whether hydrochloric acid was still coming off. Even after the lapse

of so long a time as this it was found that the loss of hydrochloric acid continued, although it was slight. On analysis this gave ZrO_2 42.28 per cent., and Cl 24.35 per cent. Although the results in this and the experiment immediately preceding correspond fairly well, they are unsatisfactory as they point either to a mixture of chlorides or an oxychloride of very complicated formula and hence unsuited for the ultimate aim of the research.

Lastly a portion was placed over concentrated sulphuric acid and the atmosphere above it exhausted occasionally. This was kept up during two months of summer weather. The loss in the last fifteen days was about 0.02 per cent. of the whole. The mass was powdery with a slightly discolored crust. It was all soluble in water, however, and yielded a clear colorless solution. It contained 53.30 per cent. of ZrO_2. This corresponds very nearly to the formula $ZrOCl_4.3H_2O$.

This last experiment showed the possibility of securing pure zirconium chloride, provided the excess of hydrochloric acid could be removed. It was thought that this might be done by heating in an atmosphere of hydrochloric acid. A weighed flask was so arranged that it could be kept at a definite temperature while a stream of dry hydrogen chloride was passing through it. The temperature ranged from 100° to 110° C., and the chloride placed in the flask melted, solidifying again after the loss of the water and excess of hydrochloric acid. If the drying was done slowly enough, apparently crystalline oxychloride was gotten which lost no further weight on being kept at 100° C. A more rapid drying left a hard white mass quite hygroscopic. Heating this mass for several days did not cause any diminution in weight, provided the flask was kept full of hydrogen chloride. If the mass was heated even a short time in the absence of hydrogen chloride then further heating caused a continuous loss of weight even in the presence of a rapid stream of hydrogen chloride. After this it was impossible to secure a constant weight.

This method of drying has been tried repeatedly on various preparations and I regard the facts stated above as showing conclusively that a neutral zirconium chloride can be prepared and dried.

Analyses of this chloride gave the following percentages of ZrO_2:

52.70 52.78 52.63

Believing that a simple compound of zirconium and chlorine had been obtained corresponding to the formula $ZrCl_4$ a series of determinations were undertaken with a view to securing data for calculating the atomic weight.

This chloride obtained by recrystallization from concentrated hydrochloric acid had also been analyzed by Linnemann (Lond. Chem. News LII, 233-240) and the percentage of zirconium found led him to believe that it was the tetrachloride. The determinations made by one of us with a view to securing data for recalculating the atomic weight were ten in number. They were made with great care and yielded a mean of 52.986. This would have corresponded to an atomic weight of 91.75 if the body were really the tetrachloride. To settle its exact composition the chlorine was determined in a sample dried also in hydrogen chloride. Two determinations gave the mean percentage of chlorine as 35.26. This result is entirely too low for the tetrachloride which would require 61.01 per cent. of chlorine. The substance analyzed was then manifestly an oxychloride but none of simple composition could be calculated from the results. The formula which seemed nearest to it was $Zr_3(OH)_5Cl_7.5H_2O$. (see J. Am. Chem. Soc. 1895. p. 842). The subject was then allowed to drop for two years, except that the chloride was tested for water and found to give it off abundantly at 180°–210°.

During the past summer the accuracy of the chlorine determination was brought into question. Determinations were made on other samples and the percentage of chlorine was found to be 29.98. The error of the previous deter-

mination may have been due to the sample or to manipulation. Which was at fault cannot well be decided now. The new determinations give

	Calc. for $ZrOCl_2.3H_2O$.
Zr. 38.99	39.12
Cl. 29.98	30.66

This oxychloride is therefore, after drying, identical with the one obtained by crystallization from water after it also has been dried.

The amorphous (?) form, insoluble in concentrated hydrocloric acid but easily soluble in water has been analyzed by Paykull and he has calculated the formula $2ZrOCl_2.13H_2O$. This insoluble oxychloride is nearly always present during the process of purification by recrystallization from hydrochloric acid. Repeated boilings with hydrochloric acid fail to dissolve it. A sample was prepared by allowing a very concentrated aqueous solution of the oxychloride to fall drop by drop into concentrated hydrochloric acid. It was washed with hydrochloric acid and then boiled. After pouring off the acid the mass was washed with a mixture of nine parts ether and one part alcohol. It was dried between filter paper. Little assurance could be felt that this mode of drying removed all the hygroscopic moisture. It was analyzed in this condition. Another portion was placed over caustic alkali (after pressing between filter paper) and yet another portion was dried at 105° in a stream of hydrogen chloride.

The analysis of the portion dried between filter paper was as follows: (no difference was observed in that over caustic alkali after two days).

	Calc. for $ZrOCl_2.6H_2O$.
Zr. 31.72	31.70
Cl. 20.81	21.01

This is therefore in close accord with the formula $ZrOCl_2.6H_2O$. The portion dried under hydrogen chloride was small and only the zirconium was determined. The percentage of this corresponded fairly with $ZrOCl_2.3H_2O$.

Summarizing our examination of these oxychlorides then, we find that there are three.

1. An oxychloride gotten in large, well-formed crystals by crystallization from water. These crystals lose slowly both water and hydrochloric acid on exposure to the air. Their formula is $ZrOCl_2.8H_2O$.

2. An oxychloride gotten by precipitation by hydrochloric acid from an aqueous solution. This is insoluble in hydrochloric acid. It is seen in silky crystals or a white mass of very fine crystals. The formula is $ZrOCl_2.6H_2O$.

3. An oxychloride gotten by crystallization from hydrochloric acid. This has the formula $ZrOCl_2.3H_2O$.

When any one of these is dried at 100—125° with a stream of dry hydrogen chloride passing over it three molecules of water of crystallization are left and the oxychloride has the formula given under 3. namely $ZrOCl_2.3H_2O$. These last molecules of water are lost at a temperature of 180—210°.

Weibull (Ber. 1887. 1394) gives the measurements of the crystals of the oxychloride formed from water. They belong to the tetragonal system, are optically unaxial with double refraction.

Several times during the examination of these oxychlorides the formation of a hydrogele was observed. The exact conditions under which it was formed were not determined. The tendency to form this hydrogele is much less than in the case of the bromides and iodides. Similar compounds will be mentioned there.

III. ZIRCONIUM BROMIDES.

Zirconium tetrabromide, $ZrBr_4$, is formed by conducting bromine vapor over a heated mixture of zirconium and carbon. A stream of carbon dioxide may be used for carrying the bromine vapor. It forms a white crystalline (microscopic) powder which can be sublimed but is decomposed by water, (Melliss J. 1870. 328:).

Zirconium oxybromide may be formed by decomposing

the tetrabromide with water and also by dissolving zirconium hydroxide in hydrobromic acid (Gmelin, Handbook, 6th ed'n. II. 1. 706.) It crystallizes from the aqueous solution in fine transparent needle like crystals containing water of crystallization (Melliss, Mats Weibull B. 1887. 1394).

Weibull gives the following analyses:

			Calc. $ZrOBr_2.8H_2O$
Zr	20.35	20.83	21.87
Br	41.16	38.70	39.05

He says that the crystals are isomorphous with those of the oxychloride which seems to be true. They are much more hygroscopic. His two analyses are decidedly discordant and one would judge that the amount of water of crystallization had been decided upon from the analogy to the oxychloride.

The oxy-bromides described in the following experiments belong to two types with varying degrees of hydration—$ZrOBr_2$ plus x H_2O, where x equals 3, 13, or 14 and $ZrBr(OH)_3$ plus yH_2O where y equals 1 or 2. All of these compounds are deliquescent and decompose on exposure to moist air, the clear white crystals, often colored pink by free bromine present, melting to a gum, frequently with the evolution of hydrobromic acid. The salts are unstable even in dry air as was found on exposing dried crystals upon a watchglass in a desiccator containing sulphuric acid. Much hydrobromic acid was evolved in the decomposition.

The crystals were prepared in two ways:—either by dissolving pure $Zr(OH)_4$ in dilute hydrobromic acid evaporated upon water bath with subsequent additions of 48 per cent. hydrobromic acid and repeated evaporations, or a concentrated solution of hydrobromic acid was saturated with $Zr(OH)_4$, evaporated and the crystals obtained on cooling.

As a rule the crystals obtained were quite soluble in the hot acid but separate at once on cooling. In the heating necessary for the thorough saturation of the hy-

drobromic acid by the $Zr(OH)_4$ the solution first becomes straw colored then a deeper red depending upon the time of the heating. This is evidently due to bromine from the decomposition of some hydrobromic acid by organic matter in the air.

A difficult problem was the removal of the strong hydrobromic acid mother liquor and the free bromine nearly always present with the crystals. Of the methods tried to effect this none proved satisfactory. The crystalline mass was in one case six times washed with ether, the yellowish red solution, due to dissolved bromine, being decanted. Filtering proved too slow permitting a rather long exposure of the crystals to the moisture of the air. After this washing with ether the crystals still slightly yellow colored were placed in a "vacuum" desiccator for the removal of the remaining ether. The small glass dish containing the material was allowed to remain 36 hours in the vacuum desiccator. The substance was then removed, dried between filter paper and analyzed.

		Found		Calc. for $ZrOBr_2.13H_2O$
ZrO_2	24.15	24.50	24.60	24.01
Br		32.29		31.93
H_2O 124°C		24.44		

This substance gave evidence of decomposition after being placed in the weighing bottle.

Another method used for the removal of bromine was washing the colored crystals three times with strong (48 per cent.) solution of hydrobromic acid. Most of the bromine was thus removed, although the salt remained slightly yellow, possibly due to the remaining hydrobromic acid. An interruption of the work at this point required the salt in this state to be placed in a desiccator over sulphuric acid. It remained there for several days when the work was resumed. All moisture seemed to be removed and great volumes of hydrobromic acid were given off when the desiccator was opened. The substance had taken on a brownish-red color around the edges

but the central portion was perfectly white. To remove the excess of acid the substance was washed quickly three times with small amounts of water. All of these salts are exceedingly soluble in water and the utmost care is necessary to avoid the entire resolution of the substance. The wash-water was deeply colored by the bromine removed and the salt remained pinkish. It was dried on filter paper and an analysis gave:—

ZrO_2	24.54

This shows that the method of removing the bromine and hydrobromic acid and drying the crystals did not materially alter their composition. Alcohol did not give satisfactory results.

The ether-washed crystals after being allowed to stand in a glass stoppered weighing bottle in the balance case for several weeks showed evidence of absorbed moisture. They were dried again by pressure between folds of bibulous paper, but they could not in this way be brought back to the same state as before, as shown by the analysis:—

	Found	Previously Found	Calc. for $ZrOBr_2.14H_2O$
ZrO_2	23.49	24.50(av.)	23.70
Br	30.58		30.82

About 4 grams of these crystals were dried in a glass stoppered flask under a rapid stream of dry hydrobromic acid at a temperature varying between 100° and 120°. The average temperature was about 110° and the drying lasted continuously through three and a half days. After cooling, perfectly dry air was drawn through the flask for a little over ten minutes. This was evidently not long enough as all the free hydrobromic acid had not been removed as shown by the analysis. The substance dried down to a hard white crystalline state which was quite soluble in water. The composition of this residue was as follows:—

ZrO_2	34.91	34.82
Br	50.05	

If an allowance of 4.5 per cent. be made for the extra

hydrobromic acid not removed, for thirty minutes should have been allowed for the removal of all the acid as was found in the work on the oxychlorides we have:—

	Found	Calc. for $ZrOBr_2.4H_2O$.
ZrO_2	36.31	36.21
Br	47.80	47.30

Of course such a calculation is not allowable and is given merely to show the possible composition of the dried mass. The experiment was not repeated on account of expense as to both time and materials.

One hundred cubic centimetres of 48 per cent. hydrobromic acid solution were saturated with $Zr(OH)_4$ by continuous boiling. The volume reached at least 500 cubic centimetres before the hydroxide ceased to be taken up. The solution was never perfectly clear until it was twice filtered through compact filter paper doubly folded. The clear yellow solution was concentrated by evaporation on the water bath. The more concentrated it became the redder it was, finally the color was so deep that it appeared almost black. This was due to decomposition of the hydrobromic acid by organic dust in the air no doubt.

After concentration the liquid was cooled and white crystals separated out. On allowing it to stand 24 hours, or always when made too concentrated by further evaporation, a red jelly separated on top the crystals. In trying to wash this red jelly from around the crystals, for it was very soluble in water, the crystals were also dissolved. The whole was therefore redissolved and after several attempts a set of prismatic needles 1—2 millimetres in length separated out free from the jelly. This jelly was not silicic acid as feared. The mother liquor was poured off, the crystals quickly washed three times with small amounts of water, dried between filter paper and analyzed:—

	Found		Calc. for $ZrBr(OH)_3 2H_2O$
ZrO_2	34.90	34.84	35.23
Br	30.79		31.01

The solution was further evaporated and another crop

of needle crystals, similar to, but much smaller than, the above obtained. They were washed four times with cold water, dried to a powder between filter paper and analyzed:—

	Found		Calc. for $ZrBr(OH)_3.H_2O$.
ZrO_2	36.86	36.35	37.91
Br	32.49		33.33

An investigation of the gelatinous oxybromide of zirconium showed that it was a hydrogele. On dialysis the small amount of crystalline oxybromide present passed through the membrane. At the same time the gelatinous compound, if it may be so termed, slowly decomposed into zirconium hydroxide and hydrobromic acid, the latter gradually passing through the septum while the former remained behind.

ZIRCONIUM IODIDE.

Zirconium tetraiodide has been prepared by Dennis and Spencer Jour. Amer. Chem. Soc. XVIII. 673) by passing hydrogen iodide over heated zirconium. I is singularly different from the corresponding chlorine and bromine compounds. It forms a white crystalline sublimate insoluble in water and acids, not hygroscopic and showing no tendency to form oxyiodides with water.

According to Melliss zirconium oxyiodide is not formed by dissolving $Zr(OH)_4$ in HI. Hinzberg Annalen 239. 253) secured an oxyiodide by precipitating a solution of $Zr(SO_4)_2$ with BaI_2 in equivalent amounts. The solution was evaporated over H_2SO_4 and the crystals washed with carbon bisulphide and the analysis gave $ZrI(OH)_3.3H_2O$.

In our experiments we found that zirconium hydroxide when precipitated cold was soluble to a small extent in strong aqueous hydriodic acid or could be dissolved by passing hydrogen iodide into water in which the zirconium hydroxide was suspended. Evaporation of this solution over sulphuric acid or calcium chloride gave

needle like crystals strongly colored with iodine and very hygroscopic. Every attempt failed at getting these freed from excess of iodine and properly dried. Washing with ether or with carbon bisulphide was ineffective. A hydrogele was gotten by acting upon zirconium hydroxide with hydrogen iodide which formed on drying a hard horn-like, slightly colored mass, insoluble in water and acids. This contained

Zr 32.14 I. 27.88 H_2O(by difference)28.64

It lost only 11.07 per cent. of its weight after three hours heating at 100—120°.

THE GLABROUS-LEAVED SPECIES OF ASARUM OF THE SOUTHERN UNITED STATES.*

W. W. ASHE.

The following notes on the glabrous-leaved group of the genus Asarum are based on a field study of the genus

*While this paper was intended for this JOURNAL its earlier publication as a separate with no credit to this JOURNAL has rendered a few changes necessary in regard to the glabrous-leaved group, while the references to the Canadense group have been entirely omitted since Mr. E. P. Bicknell is at present working on this group.

Since this article was put in type I have received a letter from Mr. E. G. Baker, of the Kew Gardens, in reply to one I wrote him, which may throw some additional light on the identity of the Linnæan *Asarum Virginicum*. A comparison of my plants with the Gronovian specimen in the British Museum, on which the Linnæan species is based, was made for me by Mr. Baker. It showed that the Gronovian specimen was more like *A. minus*, but was a smaller plant than that and with a smaller flower. There is an *Asarum* found in the coastal region of North Carolina belonging to this group, and having smaller leaves than any of the Appalachian species, but I have not yet been able to secure flowers from it. It is possible that it may approach in the size and shape of the calyx more closely to the Gronovian specimen than does *A. minus*; but this is mere speculation, so that for the present it is probably better to regard *A. minus* Ashe as *A. Virginicum* L.

extending over several years, so that I have been able to examine growing all the species described except A. heterophyllum ochranthum, and A. callifolium.

Herbarium material, unless carefully prepared and not too heavily pressed, is unsatisfactory, and gives only a slight idea of the natural shape of the calyx, in which lies the chief difference between these species. For the coriaceous-leaved species the shape of the prolongation of the style beyond the stigma offers good group-characters for determining herbarium material. I have found scarcely any difference in the seeds; and have been unable to secure capsules for satisfactory examination, so I cannot say what characters they offer. Neither the roots nor bracts offer any specific character. The leaves of all the species of this group are at times spotted with white; more frequently this is the case when the plant grows in the shade.

The coriaceous-leaved species are southern Appalachian, with the centre of their distribution in the mountains of North Carolina. One species only, *A. arifolium*, extends into the coastal plain region of the Atlantic States. All the species except *A. arifolium* are rather local.

The nomenclature of the Virginicum group presents some difficulty as to which species represents the original *Asarum Virginicum* of Linnæus. Plukenet's figure (Alm. 55. t. 78. f. 2.) to which Linnæus refers might represent any species of this group: it poorly figures *A. macranthum;* somewhat better *A. minus;* and might have been intended to represent either *A. Hemmingeri* or *A. heterophyllum*. The Gronovian description does not add any information. I have thought it preferable to follow the practice of several European botanists and ignore, in such a case of uncertainty, the Linnæan name, as it represents a group of at least four species rather than a single plant.

I have to thank many friends for material furnished

me at different times or for permission to examine their material or material placed under their care.

SYNOPTICAL ARRANGEMENT OF GLABROUS-LEAVED SPECIES.

Annual leaf solitary, glabrous, thick, the single flower from the axil of the ovate or reniform subtending bract; calyx glabrous without; the very short epigeal erect or ascending rootstock several times dichotomously forked; roots clustered, thick, numerous, fleshy; anthers oblong-linear, sessile or nearly so, the filaments not prolonged; the 6 thick divergent styles usually 2-forked or notched, bearing the extrose raised stigma below the summit.

(a.) Leaves round-cordate at base; the styles not cleft to the top of the stigma; anthers pointless. (These species except the last constitute the *Asarum Virginicum* of Linnæus.)

(b.) The stout prolongation of style barely notched, much wider than the small orbicular stigma.

(c.) Calyx cylindro-campanulate, somewhat contracted at the throat.

2. ASARUM MACRANTHUM (Shuttlw.) Small, Mem. Torr. Cl., 5:136.

Homotropa Macranthum Shuttlw.; Small Mem. Torr. Cl., 4:150, as synonym.

Asarum Virginicum var. *grandiflorum*, Mx. in D. C. Prodr. 15:426.

2. ASARUM MINUS W. W. Ashe, Contrib. from Herb. No. 1, (1897).

Leaves as in the above but rarely orbicular; tube of calyx cylindro-campanulate, about 1cm wide, about the same length, the very short lobes spreading; peduncle as long as the flower, the large bract pointed; projection of the style very short; the seed oblong.

North and South Carolina and Tennessee. Local. In North Carolina it occurs as low as 150m above sea level. Type locality: Chapel Hill, N. C.

(c) Calyx campanulate or oblong-campanulate, not contracted at the throat.

3. ASARUM HETEROPHYLLUM, W. W. Ashe, Contrib. from Herb. No. 1. (1897).

Leaf-blades orbicular, ovate or triangular in outline, cordate at base (or occasionally almost hastate), about

the same size as in the above; calyx campanulate, rounded at base, the tube .7-1cm long, the lobes nearly equaling it in length, .8-1cm wide at base; orange-purple, or purple-brown without, brighter within; the very stout barely notched style much prolonged beyond the minute round stigma; capsule short, cylindrous, barely as long as the stamens, scarcely distending the calyx; seed oval.

Mountains of North Carolina, Tennessee and Virginia. Frequent. At once separated from the preceding species by the campanulate calyx, and from *A. Memmingeri* by its open throat and longer calyx lobes.

ASARUM HETEROPHYLLUM OCHRANTHUM, W. W. Ashe, Contrib. from Herb. No. 1. (1897).

Calyx yellow or orange, oblong-campanulate, the spreading lobes as long as the 1cm long tube. No. 18,263 U. S. Nat. Herb.; East Tennessee : E. E. Parry.

(b) Calyx urceolate or somewhat contracted at the mouth, the oval stigma thicker than the slender deeply 2-parted projection of the style, and placed near the base of the style.

4. ASARUM MEMMINGERI, W. W. Ashe, Contrib. from Herb. No. 1. (1897).

Leaf-blades about the size of those of *A. macranthum*, nearly orbicular and retuse, or less commonly ovate, their margin entire; petiole often scarcely longer than the leaf-blade; calyx 1.2-1.5cm long; urceolate or urceolate-campanulate, the mouth 7mm or less wide, the short lobes barely 3mm long; the large oval stigma near the base of the style, the very slender, deeply bifid or rarely entire projection as long the stigma; capsule short-cylindrical, when mature greatly distending the calyx; seed sharply triangular.

West Virginia to North and South Carolina. Frequent above 700m altitude. Type locality: Mitchell county, N. C. Named for Mr. E. R. Memminger.

5. ASARUM CALLIFOLIUM Small, Bul. Tor. Cl. 24:7.

Leaf-blades ovate, crenulate on the margins; petiole 2-3

times as long as the leaf-blade, slightly pubescent; bracts reniform; peduncles not longer than the calyx; calyx urceolate, 1.5-2.5cm long, dark green without, purple within, the segments broadly ovate; the large oval stigma at the base of the style, the slender projection deeply 2-cleft.

West Florida. A species recently described by Dr. Small from Dr. Chapman's collection.

(a) Leaf-blades, or some of them, halbert-shaped at base; the projection of the style cleft to the top of the large ovate stigma; anthers short-pointed.

6. ASARUM ARIFOLIUM Michx. Fl. Bor. Am. 1:279.

Asarum Virginicum Walt., Fl. 143.

Leaf-blade 6-10cm long, 5-12cm wide, ovate or triangular in outline, halbert-shaped, or rarely round-cordate at base, rounded or pointed at the apex; petiole short or long; calyx from 1.5-2.3cm long, urceolate, rounded at base, much contracted at the throat, the triangular lobes spreading, firm in texture, greenish-purple without, purple-brown within; stigma large, ovate, at the base of the style, the prolongation cleft to the top of the stigma.

Virginia to southern Georgia and Alabama. Common throughout its distribution. Extends in the Carolinas from the sea level to an altitude of about 600m. Probably does not occur in the mountains of Virginia, all specimens which I have seen from there being referable to the next. A very variable species both in habit and form.

7. ASARUM RUTHII, W. W. Ashe, Contrib. from Herb. No. 1. (1897).

Leaf-blades halbert-shaped, usually broader than long, commonly larger than in the preceding, deep green; calyx cylindro-ovate, rounded and larger at the base, gradually narrowed toward the mouth, 2.5-3cm long, 1-1.2cm wide, the rounded lobes barely 5mm wide at base, not spreading, purplish-green without, duller within; stigmas and styles similar to those of the preceding.

Southwestern Virginia to Alabama in the mountains, but not occurring above 800m. Named for Prof. Albert Ruth, who sent the species to me. At once separated from *A. arifolium* by its cylindrous calyx, its tube not being contracted at the throat as is that of *A. arifolium*. Type locality: Morristown, Tenn.

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FOURTEENTH YEAR—PART SECOND.

1897.

A REVISION OF THE ATOMIC WEIGHT OF ZIRCONIUM.[1]

BY F. P. VENABLE.

PREVIOUS DETERMINATIONS OF THE ATOMIC WEIGHT.

It is perhaps best to give here a brief outline of previous determinations of the atomic weight of zirconium. Six such series have come under my notice. In three of these the sulphate was used, and in the others the chloride and the double fluoride of zirconium and potassium were used, and in one the selenate.

The determinations of Hermann,[2] by means of the chloride, can be dismissed as untrustworthy, because of his failure to overcome the difficulties inherent in the use of the chloride as shown by Bailey's work and my own.

The work of Marignac upon the double fluoride I am not in a position to criticise properly, except in so far as to say that his analyses are not very numerous, and that they show a range of nearly three units in the atomic weight.

In 1825 Berzelius ignited the sulphate and gave six determinations of the ratio of the sulphate to the oxide. In

[1] Read at the Washington Meeting American Chem. Society.

[2] *J. Prakt. Chem.*, *31*, 77

some of the experiments he also precipitated the zirconium hydroxide by means of ammonium hydroxide and determined the sulphuric acid in the filtrate by precipitation with barium chloride.

Mats Weibull also used the sulphate and reports seven experiments with an entire consumption of 8.2335 grams. Bailey's own determinations number eight, using in all more than sixteen grams. He gives full data as to his work, and it is well done and merits very careful attention. The following table is copied from his article.[3] The figures have been recalculated to the basis of O=16.

	Mean	Maximum	Minimum	
Zr : Cl	88.77			Hermann
ZrO_2 : HCl	90.14	90.98	89.29	Hermann
K_2ZrF_6 : K_2SO_4	90.53	92.80	90.06	Marignac
ZrO_2 : K_2SO_4	90.64	91.26	90.24	Marignac
K_2ZrF_6 : ZrO_2	90.8	91.3	89.9	Marignac
$Zr(SO_4)_2$: ZrO	89.45	92.65	89.27	Berzelius
$Zr(SO_4)_2$: ZrO_2	89.48	90.38	89.13	Mats Weibull
$Zr(SO_4)_2$: ZrO_2	90.65	90.78	90.46	Bailey

It is manifest that the determinations based upon the ignition of the sulphate are the only ones worthy of further attention. A brief criticism of these is necessary. First, as to Mats Weibull, Bailey says that the temperature used by him in freeing the sulphate from the excess of sulphuric acid was some 50° too low. This would of course give him variable and low results. Berzelius does not give exact data as to temperature used, but he seems to have heated the sulphate too high in driving off the excess of acid. Possibly more stress is to be laid upon the question of the purity of his sulphate and the correctness of the assumption that he had in hand the normal sulphate.

Bailey concludes from his experiments that the sulphate is stable up to 400° C., and that the excess of sulphuric acid can be completely driven off by the use of a temper-

[3] *Chem. News*, 60, 17.

ature between this and 350° C. He further states that a mixture of the salt and free acid, as prepared by him, when heated to this temperature until constant, yields the normal sulphate. It must be said that he gives no proofs of this beyond the amount of zirconia found in his atomic weight determinations.

Whilst certain criticisms of the work of Bailey have occurred to me, I will refrain from mentioning them until I have had opportunity to repeat his experiments and so make myself more familiar with the details of his method.

One criticism I can venture upon now, however. I doubt whether it is possible to ignite, without loss, zirconia along with ammonium carbonate, as was done by Berzelius and by Bailey to remove the "last two or three milligrams of sulphuric acid." I have not ventured to use this method in getting rid of the chlorine which is held just as tenaciously as the sulphuric acid, as I feel sure that it could not be done without loss. Bailey adopted extraordinary precautions to prevent this loss, but it seems to me that it is not the currents of the external atmosphere, as he maintains, which are to be most avoided, but the mass of escaping vapor of the ammonium salts. It is easily possible for him to have lost several milligrams of the finely-divided zirconia in this way, and as he states, each milligram was equivalent to a variation of 0.25 in the atomic weight.

THE WEIGHINGS.

In the following experiments the amounts of substance used varied from one to five grams. To avoid the disadvantage of a small error causing a large variation in the result, I would gladly have used larger amounts of the chloride, but many difficulties met me there. The purification of the zirconium oxychloride is slow and costly. It is best carried out in small portions of a few grams at a time. Some fifty grams have constituted the stock at my

command. The drying of large portions and the subsequent ignition would be exceedingly tedious and time consuming, besides requiring such apparatus as could not be well afforded. Five or six grams have been about the largest amounts that could be well handled at one time. Even such an amount as that required from sixteen to twenty days for the completion of the experiment. It could not safely be hurried through in shorter time.

The weighings were carried but upon an excellently constructed Sartorius balance, intended for a load of 200 grams. The heaviest apparatus used weighed less than sixty grams. The weights were corrected by one which had been compared with the standard at Washington. All objects were weighed against a tare of as nearly the same size, form, and weight as possible, all of the flasks, crucibles, etc., being made in pairs. This partly avoided the necessity for a reduction of the weighings to a vacuum and corrections for moisture, pressure, etc. Such corrections would have had little meaning in comparison with the other inaccuracies of the process and manipulation, and could only serve to give a false appearance of excessive accuracy. The objects were left one-half hour in the balance-case before weighing, experiments having shown that this time was sufficient. Of course the adjustment of the balance was carefully watched, and the balance, which has been used very little, was put to no other use during the progress of these experiments.

METHOD OF WORK.

The purified oxychloride was introduced into a small glass flask having a capacity of 100 cc. This was provided with a glass stopper ground to fit, and also a second one with two tubes arranged for the passage of the hydrochloric acid gas. The arrangement of the tubes was similar to that in an ordinary ether wash-bottle, though both tubes outside were bent downwards and had little

bulbs blown in them for catching moisture, etc. A Thörner bath was found to be very convenient for keeping these flasks at 100° C. The hydrochloric acid was prepared by allowing sulphuric acid to drop into a large flask containing the hydrochloric acid. The gas thus obtained in a regular stream, was passed through a wash-bottle containing sulphuric acid and then through towers filled with glass beads kept moist with concentrated sulphuric acid.

The drying took from fifty to one hundred hours (in some extreme cases.) If the stream of gas was rapid the temperature could rise to 110° or even higher without decomposition of the chloride. A much lower temperature caused this decomposition if the stream was insufficient to keep the flask full of gas. A number of experiments were carried out showing these facts. Indeed, two in the series of determinations were lost by the stream of gas becoming too slow or altogether ceasing for a short while. (Experiments VI and VIII.) It was thought from experiments at first that where this decomposition had begun it was impossible to secure a constant weight of the residue, but this is certainly not true where the decomposition has been only slight. Of course this introduces a chance for error in the method. The drying must be watched quite closely, and not more than eight or ten hours of drying could be easily managed in a day.

At first it was feared to remove the atmosphere preparatory to weighing, and efforts were made at weighing the flasks full of hydrogen chloride. These results were too low and varied among themselves, so that it was evidently impracticable to carry out the experiments in this way. It was found that the hydrochloric acid could be replaced by dry air. The flask was removed from the bath and dry, pure air passed through it for half an hour. It is of course essential that the air be carefully dried. The tubes were then removed and the glass stopper quickly

fitted in its place. It was then ready for placing in the balance-case. The chloride is deliquescent and some trouble in weighing was experienced. If the stopper was well ground there was no appreciable change in the weight in from twenty to forty minutes after placing upon the balance. The loss of weight in the latter part of the drying was very slow. The weighings were taken at intervals of from six to eight hours' heating. The number of weighings necessary before constancy was secured served as a safeguard against error. A series of such weighings is given further on.

After drying, the chloride was dissolved in a small amount of water (redistilled) and this solution, with rinsings, transferred to a platinum crucible. It was evaporated to dryness upon a water-bath, with due precautions against dust, etc., was next heated gradually upon a sand-bath until most of the chlorine had been driven off, and was then slowly raised to the highest temperature attainable by the Bunsen burner. During this latter part of the operation the cover was kept on. Three or four days were thus consumed, the gradual heating giving a coherent flinty mass of glistening semi-translucency which could be safely heated by the water-blast without loss. During the driving off of the chlorine the platinum crucible was more or less attacked, but as this was before the lid was on, there was little chance of loss from this source. This corroded platinum was probably the reddish-brown decomposition product mentioned by Bailey as coming from the ignition of the oxychloride.

The last of the chlorine was driven off by heating with a water-blast for from forty-five to seventy hours. The last weighings were made at intervals of from six to twenty hours and were recorded as constant if they agreed within 0.00005 of a gram. A series of weighings is here given as an example. Experiment No. II, or the first

one successfully carried out in the series, is taken for the purpose.

Weights of zirconium oxychloride:					March 28	5.25910
"	"	"	"	"	29	5.25786
"	"	"	"	"	30	5.25760
"	"	"	"	April	1	5.25762

Weights of zirconium oxide:					April 11	2.78759
"	"	"	"	"	12	2.78724
"	"	"	"	"	13	2.78583
"	"	"	"	"	15	2.78517
"	"	"	"	"	16	2.78452
"	"	"	"	"	17	2.78451

This zirconia was examined for chlorine in most of the analyses and was found to be free from it. In the last three experiments reported in the series, the ignited residue was treated with hydrofluoric acid. Ignition after this treatment was very difficult, as the mass was not compact and coherent. The finely divided zirconia was lost in spite of the most careful treatment. The first was lost altogether and the weighing was not carried out. The second showed, upon the lid signs of the powdered zirconia having been swept out. The total loss of weight, however, was less than one milligram. This could readily be attributed to the zirconia and pointed to the absence of silica unless in insignificant traces.

I think great purity may be claimed for the preparations used in the analyses. Crystallizing from hot hydrochloric acid is apt to remove most known impurities, and they were eliminated beyond the possibility of detection by the ordinary tests. The analyses were not made from the same preparation, but from small quantities prepared at different times and some crystallized ten or a dozen times more than others, yet no appreciable difference could be detected in the results. That these results are not in close accord with one another, is due in part to the deliquescence of the chloride and to the risks involved in the prolonged heating of the oxide.

SOURCES OF ERROR.

Five main sources of error have occurred to me apart from any question as to the purity of the material.

1. The deliquescence of the chloride.
2. The loss of the finely divided zirconia.
3. The corrosion of the platinum crucibles.
4. The attack of the glass flasks by the gaseous and aqueous hydrochloric acid. It is very evident that the glass vessels would suffer when subjected to the action of hydrochloric acid during such prolonged periods. The weighings easily revealed the extent of this action. It was found to vary with different flasks. For instance, flask I lost 0.00116, 0.00031, 0.00023, and 0.00078 gram. On the other hand, flask IV weighed after the first experiment only 0.00011 gram less, and after the next two experiments the loss was 0.00013, and the total loss during three experiments was 0.00024. This is probably transferred mainly as alkaline chlorides to the crucibles and is there volatilized. Sodium could readily be detected upon the lid of the crucible after partial ignition. Of course if all is volatilized then no error is introdued into the experiment, but there may be some non-volatile material also transferred from the flasks. The total amount is so small that the error cannot be a large one.
5. Substances carried into the drying flasks by the stream of gas. Much care was taken to avoid error from this source. The main danger lay in the necessity for the use of some rubber connections. Vulcanized rubber was used. It was freed from excess of sulphur and was replaced by a fresh piece when sttacked by the gas. The dry gas does not attack rubber very rapidly. Gaseous sulphur compounds, coming from the sulphuric acid, used in preparing and drying the hydrogen chloride, were probably carried through the drying flasks, but there seems to be no probability of their causing a decomposition of the oxychloride.

THE DETERMINATIONS.

All analyses which were completed under the proper conditions of the method, as already given, are here reported. Experiment III became contaminated from the iron support during the prolonged heating and came out consequently a little high, giving the ratio of ZrO_2 : $ZrOCl_2.3H_2O$ as 53.12. In most of the subsequent analyses the ignition was carried out with the crucible suspended in a platinum wire cage from a glass support. Experiments VI and VIII were dried with an insufficient stream of gas, as already stated, and hence were partially decomposed. They gave 53.57 and 53.8, respectively. The remaining analyses follow:

	$ZrOCl_2.3H_2O$.	ZrO_2.	Ratio.
II	5.25762	2.78459	52.961
IV	3.53994	1.87550	52.981
V	3.25036	1.72435	53.051
VII	1.52245	0.80708	53.012
IX	2.98802	1.58274	52.969
X	2.11371	1.11820	52.949
XI	2.38139	1.26161	52.978
XII	1.90285	1.00958	53.055
XIII	8.61847	1.38658	52.024
XIV	1.07347	0.56840	52.951
	26.64828	14.11953	52.986

Calculating these for the ratio $ZrOCl_2.3H_2O : ZrO_2$, taking H=1.008, O=16, and Cl=35.45, we have the following:

Maximum ratio	53.055	Atomic weight	91.12
Mean "	52.986	" "	90.78
Minimum "	52.951	" "	90.61

The atomic weight as determined by Bailey is 90.65. The mean valne given in Clarke's Recalculation is 90.40. I purpose repeating the determinations with the oxychloride, with such modifications as have occurred to me since the completion of the above work.

NOTES ON DARBYA AND BUCKLEYA.

W. W. ASHE.

The limited and localized distribution of *Darbya* and *Buckleya*, two genera of southern Appalachian plants (*Darbya* a monotypic genus and *Buckleya* with one Japanese species and the east American plant which is under consideration) has frequently since their discovery been a subject of comment among American botanists. Among the chief factors which have limited their distribution, as Professor Sargent[1] has pointed out in the case of *Buckleya*, are the fact that the sexes are confined to different plants, and the rapid degeneration of the oily albumen surrounding the embryo: the first being an obstacle to the formation of seed; and the latter injuring or destroying the germinating powers of the seed unless they early reach a suitable place for sprouting. Both thus check the increase of new plants.

Another fact which has apparently been overlooked in connection with these plants and which is probably also in a large measure accountable for their localized distribution, is that no efficient means is provided for seed-dissemination. All animals that I have tried with the seed reject them; in regard to birds I cannot speak. The heavy fleshy seed have evidently been developed to sprout and grow near the parent plants. The seed of *Buckleya*, it is true, since it is found only along and near streams, are apt to be transported by the stream. This is evidently the case with *Buckleya* along the French Broad and Pigeon rivers. Kearney[2] records it as growing at an elevation of 30m above the river on the side of a wooded

[1] Gard. and Forest 3: 236.

[2] Bull. Tor. Bot. Cl. 24: 561.

bluff near the original station at Paint Rock. I have noticed it, however, only a few meters at most away from the river or from some stream.

But what I regard as restricting the distribution of the plants fully as much as any of the above assigned causes is the heretofore unrecorded fact of their parasitism. Although Dr. Gray[3] dug up *Buckleya* to remove it to Cambridge for the botanical garden at that place; and more recently Professor Sargent[4] has carried both seed and young plants from Paint Rock to the Arnold Arboretum, where a few of the plants were induced to grow, it was not noticed by either that *Buckleya* formed root-attachments to other plants. Great difficulty was encountered in inducing the plants to grow, and what is not strange, all means of propagation failed. Mr. J. G. Jack writes me that one of the plants of *Buckleya* which Dr. Gray took to Cambridge lived for a great many years beneath a hemlock where it was planted in the Botanic Garden and to the roots of which I think it had undoubtedly formed attachments.

I have been aware of the parasitic nature of these plants for several years. The parasitism of *Darbya* was first discovered, and subsequently that of *Buckleya*. In the autumn of 1894 Mr. F. E. Boynton and I collected specimens of *Darbya* near Salisbury, N. C., where I had previously noticed the plants. He had already suggested the parasitism of Pyrularia, as recently published,[5] and which I was soon after able to verify. We consequently suspected the parasitism of *Darbya*, knowing that many of the *Santalaceae* are root-parasites.[6]

[3] Gard. and Forest, l. c.

[4] Ibid.

[5] Distribution from Biltmore Herbarium: *Pyrularia oleifera* Mx, parasitic on roots of trees etc.

[6] Hieronymus (Die Natuerlichen Pflanzenfamilien von Engler und Prantl, 203) gives only the following genera as being root-parasites: Osyris, Santalum, Commandra, Thesium, Arjona, and Quinchamalium.

On carefully digging up the plants the roots, or what I rather regard as prolonged subterranean stems, were found to be very much as Miss K. A. Taylor[7] has described them. The plants propagate by these underground stems which are 8-15mm in thickness and similar to those of *Commandra*, but larger. These, in the centre, are firm, tough and woody. This core of wood is covered with a thick, tough, though rather corky bark, 3-4mm in thickness. From the lower side of this are frequent small roots, none of them over 3mm in thickness which form attachments to the roots of the trees and shrubs growing around. These slender roots are attached to the host by disk-shaped haustoria, somewhat similar in structure to those described for *Commandra*.[8]

Miss Taylor[9] gives the length of the "roots" dug up at Columbia, S. C., as being only a few yards. They are frequently very many yards in length, however. One plant I recently had dug up, had an unbroken stem measuring nearly 10cm, and as there was a growing-point at only one end the length must have exceeded this. The vegetative stems are apparently developed in no regular order and from no evident buds, though this will bear farther examination. The stems lie from 12-15cm below the surface and fork at frequent but irregular intervals. The underground stems are tipped with a growing-point in appearance not unlike that of many of the large roots of plants. As this growing-point pushes forward during the season of growth, many small roots are developed from the lower side of the newly formed stem. These penetrate either straight down or somewhat laterally until they reach the roots of some tree or shrub suitable for attachment, where haustoria are formed. The longest of these roots found was about 3cm in length. While

[7] Gard. and Forest, 7: 94.

[8] Von Schrenk, Bul. Tor. Bot. Cl. 12.

[9] Gard. and Forest, l. c.

developing and before attachment is secured they are covered with thin-walled cells, but old roots which have been attached to a host-root for some time, appear to have enlarged while the walls of the epidermal cells have become thickened. It is possible that the newly developing root is capable of absorbing from the soil, while the older ones that have already made attachment are no longer able to absorb; but neither of these statements is yet definitely known to be true. And since the seedling plant of *Buckleya* as I have recently found out by planting them, is thus able to exist for some time without the intervention of attachments, it is quite possible that not only the young plants of *Darbya* may do the same, but that newly developing roots as well may possess this ability to derive nutriment from the soil. This, however, is merely conjecture. These roots showed few forks and no roots could be found, except those developed in the spring, which had not formed an attachment or were evidently broken, so it is probable that those roots which do not find attachment soon lose their vitality and die.

Polygamous plants seem to mature fruit only when fertilized by staminate plants or perhaps by other seedling polygamous plants. Near Chapel Hill in the lower valley of Morgan's creek polygamous plants are found for three or four miles along the narrow strips of alluvial soil that border the creek, but no seed are produced. This would seem to indicate that all the groups of plants along Morgan's creek have a common origin and are vegetatively produced from a common stock. The staminate plant is not found near Chapel Hill.

Near Salisbury, N. C., many groups of the sterile plants are to be found within an area of two or three square miles, but as no trace of a polygamous plant has been found within twenty miles of these groups I am inclined to trace these, as well, to a common plant and derived from it vegetatively. This view is further strengthened

by the fact that in the few localities where seed are produced both sexes occur abundantly, though usually the plants are separated into more or less evident groups, as Miss Taylor[10] observed at Columbia, S. C.

If these disassociated groups of plants are of common origin, *Darbya* would seem to be, under its natural conditions, a plant which readily and rapidly propagates. In one place the underground stem seemed to have made as much as three feet of growth in one year.

I have extended the distribution of *Darbya* as far north as Halifax county, southern Virginia. Dr. Mohr has found it as far west as northern Alabama; and in Georgia it has been found as far south as Macon. The most eastern place where it has been found is near Willardville, Durham county, N. C. I have recorded from my own observation thirteen stations for the plant in Virginia and the Carolinas, the numerous groups of plants around Salisbury and Chapel Hill, and similar groups at other places, being regarded as constituting a single station. At only three of these stations are seed known to be produced. The staminate plants are much more abundant than the polygamous.

As in the case of *Commandra* attachments are made to the roots of most trees and shrubs. The following have been verified to serve for *Buckleya:* Quercus alba, Q. minor, Q. velutina, Q. Marylandica, Q. nigra; Pinus echinata, P. Virginiana; Hamamelis; Vaccinium corymbosum, V. vaccillans; Hicoria Carolinae-Septentrionalis, H. alba; Crataegus sp. ign.; Acer rubrum. It is probable that this list could be extended by carefully following the roots.

Darbya, I am convinced, can be grown by planting the seed among trees or shrubs that will serve as hosts in a place where it will not be necessary to move it. If it is desired to move the plants the seed should be planted in

[10] Gard. and Forest, 7: 94.

jars with seedling oaks or pines, and when large enough to set out remove the contents of the jar without disturbing the roots of the plants.

Buckleya, since it sometimes reaches the size of a small tree, is the largest known American parasite. It has many more fibrous roots than *Darbya* and the subterranean stem is not so extensive. The clasping disks by which attachments are made are larger and somewhat more cup-shaped than are those of *Darbya*. It is chiefly parasitic on the small roots of hemlock, beech, sugar maple, birch (sp. ind.) and red oak. It can be cultivated in the same manner as *Darbya*.

The manner of propagation of *Pyrularia* is like that of *Darbya* but the underground stems are shorter and more abundantly supplied with small roots.

ROBINIA BOYNTONII SP. NOV.

[1]CONTRIBUTION FROM MY HERBARIUM. NO. II.

W. WILLARD ASHE.

For many years a plant which was originally described by Pursh[2] as *Robinia hispida* var. *rosea* has been confused with the *Robinia hispida* of Linnæus by both American and European authors. This confusion originated from the inadequacy of Pursh's[3] description; and has been continued by later writers who, having no specimens of Pursh's plant for comparison, transferred its name to smooth or nearly smooth forms of *R. hispida* which seemed in part to agree with the description of the variety *rosea*. As a matter of fact the variability of

[1] Recieved March 18th, 1898.

[2] Flora Amer. Sept. 2: 488.

[3] *Robinia rosea B.* R. foliolis plerumque alternis, ramulis glabriusque.

hispida in those characters which were usually relied upon for segregation has justified it.

Pursh, in spite of his brief and unsatisfactory technical description, in making some general references to the distribution, etc. of the plants he had just described, compares the relative sizes of *R. hispida* and *R. hispida* var. *rosea* in such a manner as to leave no doubt in regard to their identity: "The variety *B* is less hispid and grows to a considerable large upright shrub, whereas the original *hispida* is a low straggling plant." This acurately presents the salient features of the habit of the two plants, and enables one, familiar with both in the field, to easily differentiate the true *rosea*.

But while usually a form of *hispida* is referred to *rosea*, in the last edition of Gray's Manual of Botany[4] the description of *hispida* includes not only all the true forms of *hispida*, but the *rosea* of Pursh as well, the latitude of the description embracing plants with "less bristly or naked branches, smaller flowers etc." than the immediately preceding technical description covered. The allusion to small-flowered forms can only be interpreted as a reference to *rosea*, as a comparison of the description of the two plants which follows will show.

It is probable that Marshall as well included both plants in his *rosea*, which is usually referred only to *hispida*, as he mentions the large size that some specimens of his plant attain, whereas the true *hispida* is always of small size.

American botanists, when separating the two plants at all, have retained the *rosea* under its original name, and. where first placed as a variety of *hispida* but the two plants are so different that *rosea* is eminently worthy of specific rank.

As no additional names have been proposed by European botanists there is no tortuous synonomy to be traced.

[4] Sixth edition, 134.

Robinia dubia Fouc.[5] and the other names included in its synonomy refer to a plant which has long been cultivated in Europe, and which, if not a hybrid[6] between *R. Pseudacacia* and *R. viscosa*, is a garden variety of *R. viscosa*. It is separated from the plant under consideration no less by its stout spines, than by the presence on its twigs and pods of the viscid secretion so characteristic of *viscosa*.

Since Pursh's name *rosea* is excluded by the previous use of it by Marshall and du Monceau for *R. hispida*, and no other has been published, I propose the name *Boyntonii*, complimentary to Mr. F. E. Boynton of Biltmore, N. C., an observer having a most extensive acquaintance with the southern Appalachian flora.

The proposed species is characterized as follows:

Robinia Boyntonii, sp. nov.

Robinia hispida var *rosea* Pursh, Fl. Amer. Sept. 2:488.

Robinia rosea D. C. Prod. 2:262.

Robinia hispida (in part) Gray, Man. Fifth ed. 131.

Mature twigs 3-4mm thick, terete, a bright varnished brown, glabrous; stipules minute, awl-shaped, caducous; shoot of the season at first minutely pubescent, at length glabrous or nearly so. Leaves 10-16cm long, leaflets 9-13, mostly placed alternately, short-stalked, oblong or oblong-ovate, 2-4cm long, 1-2cm wide, tipped with a slender mucro. Petiole and leaflets minutely pubescent when young, soon glabrous. Racemes axillary, erect or nodding, 7-9cm long, one-half to two-thirds the length of the leaves, rather loosely 8-12 flowered. Flowers on slender, erect or spreading pedicels 4-5mm long, rose-purple, pink, or purple and pink on the outer portion, white or much paler towards their base, when expanded

[5] In Desv. Journ. Bot. 4: 204.

[6] London (Trees and Shrubs Brit. 236) stated that it is a hybrid which originated in 1730.

barely 2cm long; blade of wing abruptly contracted into the slender claw; keel rather broad, (each portion) spatulate in outline. Calyx short, 6mm in length, as broad as long, the very short, broad lobes, 2-3mm long, abruptly acute, smooth, or minutely pubescent when young. Pod slender, many seeded, smooth, even when young.

A shrub with virgate branches, 1.5m to 2.5m in height, or exceptionally larger and assuming an arborescent form. Mountains of Virginia (?) and western North Carolina to Georgia, usually at high elevations. It is one of the handsomest of the Appalachian species of the genus, equalling in brilliance of color and abundance of flowers R. viscosa. Growing specimens of this plant have been extensively distributed by the Kawana Nurseries of Kawana, N. C.

Specimens examined:

Kelsey: Mitchell county, N. C.
J. A. Tatham: Cherokee county, N. C.
Ashe: Randolph county, N. C.
Ashe: Greenville county, S. C.

The plant is local, but fairly abundant where it occurs, and it should be frequent in cultivation. *Robinia hispida* L. with which it has been confused has the following characters:

Robinia hispida L., Mant. 1: 101.
Robinia rosea Duham., Arb. 1. *t.* 18.
Robinia rosea Marsh., Arb. 134.
Robinia montana Bartr., Trav. 335.
Pseudacacia hispida Moench, Meth. 145.
Aeschynomene hispida Roxb. (?)

Mature twigs rather stout, 4-5mm thick, terete, dark brown, bristly-hispid, papillate, or nearly smooth. Shoot of the season from densely bristly-hispid with stiff purple hairs to nearly smooth; stipules, minute early deciduous. Leaves rather large, 12-20cm long, petiole usually hispid; leaflets 7-11, rarely 13, mostly opposite, short-stalked, ovate or orbicular, 2-3cm wide, 2-4cm long,

tipped with a short, stout mucro, cordate or subcordate at base, more or less pubescent when young, soon smooth. Racemes axillary, nodding or drooping, 3-5 flowered, 4-5 cm long, one-fifth to one fourth the length of the leaves, peduncles usually hispid. Flowers purple-blue in the bud, becoming on expansion deep purple or red-purple, but lighter-colored at the base, when open 2.5cm or more long; blade of wing projecting beyond point of union with claw, so as form a narrow but deep sinus between them; each division of keel oblong, abruptly contracted into the claw. Calyx 8-10mm long, the 4-7mm long acuminate lobes much longer than the short broad generally hispid tube. Pod short, stout, few-seeded, glandular-hispid.

A low straggling shrub, 1-3 feet in height. It occurs from Virginia to Georgia and Alabama? in and near the mountains. In the mountains it is for the most part confined to the crests and dryer southern flanks of ridges, and is not uncommon. Its altitudinal distribution is from 300m to 1500m. It seems to pass gradually into the low-country form which is nearly destitute of bristles and more or less pubescent.

Robinia Boyntonii is separated from *R. hispida* L. by its greater size, smooth pod, oblong leaflets, many-flowered racemes, short calyx-lobes and smoothness.

From *R. viscosa* Vent. it is separated by having only about one-half the number of leaflets, a smooth pod and the absence of viscid secretion.

In many characters it is nearly allied to *R. Pseudacacia* L: The leaflets are about the same number, twigs and pods are smooth; but the flowers are rose-colored and smaller than in *R. Pseudacacia* and no stipular spines are developed.

Since the above was put in type I find that *Robinia* Boyntonii has been distributed by the Biltmore Herbarium, but without a name, as No. 3268: Near Highlands, Macon county, N. C.

ON THE ORIGIN OF THE VERTEBRATE SENSE ORGANS.

BY H. V. WILSON.

The belief that the chief sense organs of vertebrates have been evolved from a longitudinal series of simple and superficially situated organs rests on morphological evidence, which if not conclusive is yet very considerable.

Beard[1] in 1885 described in selachian embryos a series of rudimentary sense patches (ectodermal thickenings), on eabove each gill cleft. These he termed the branchial sense organs. Similar organs have been found by Beard and several observers (Froriep, Kupffer etc.) in the embryos of other Ichthyopsida, birds, and mammals. It may be confidently asserted that a phylogenetic significance attaches to these formations, and that the ancestors of existing vertebrates had a series of sense organs (two series, one more dorsal than the other: Kupffer) situated in the anterior (branchial) region of the body.

The sense organs of the lateral line, and of the mucus canals of the head, found in adult fishes, tailed amphibia, and in anuran larvae, are known to arise by the proliferation of the above mentioned embryonic organs, which thus became extended far beyond the seat of their original appearance.

The position and mode of origin of the embryonic nasal and auditory invaginations led Beard to regard these organs as homologous with his series of branchial sense organs. And this conclusion has been in general accepted by later investigators.

It might some years ago have seemed impossible to in-

[1] Branchial Sense Organs of Ichthyopsida. Quart. Journ. Micr. Sci. 1885.

clude the eye in this lateral series of homodynamous organs. But while the eyes (optic vesicles) ordinarily originate as diverticula from the fore-brain, it is now known that in many forms they make their appearance as invaginations of the surface ectoderm, long before the neural folds have closed. In this condition the optic vesicle is a circular depression, substantially like the auditory or nasal pit. Later these depressions are carried inwards with the invaginating neural plate, and then appear as outgrowths of the brain. The early appearance of the optic vesicles has long been known in mammals, but until within recent years it has been regarded as a peculiar and precocious feature of this group. Through the observations of Whitman[2], Eyclesheimer[3], and Locy[4], we have learned that the optic vesicles originate in this manner in several amphibia, in selachians, and the chick. These observations at least lend us a basis for the comparison of the eyes with the other segmentally arranged sense organs, and meantime (Locy lc. p. 556) "we are in the attitude of awaiting further facts."

The scattered integumentary sense organs (taste buds, touch corpuscles) have not been shown to be derived from anlages, serially homologous with the anterior segmentally arranged series.

The derivation of the chief vertebrate sense organs from a longitudinal series of superficial neuro-epithelium patches, might at first thought be construed into a sound argument for the annelid-theory of vertebrate ancestry. But when it is borne in mind that the vertebrate series is, in the embryo, confined to the anterior (branchial) region, *whence the organs spread back over the trunk and forwards over the head by proliferation*, it will be recog-

[2] Journal of Morphology, 1889, p. 593.

[3] Journ. Morphology, 1893, Vol. VIII, No. 1, p. 189.

[4] Contributions to the Structure and development of the Vertebrate Head. Journ. Morphology, 1895.

nized that this series of organs differs at any rate in the matter of distribution, from the segmentally arranged organs extending along the side of the body of certain annelids (Capitellidae, Eisig[5]; leeches, Whitman[6].)

The small number and local distribution of the segmental sense organs of the vertebrate embryo, as compared with the condition after the lateral line has become well developed, suggests inevitably the question: If so much of the metameric character of these organs in the adult (or larva) is clearly secondary, how deeply seated is the metameric arrangement of the primitive (few, embryonic) branchial sense organs? Is it possible that this series of organs has arisen from a single pair (one on each side of the body), as some (Brooks[7]) believe the gill clefts to be traceable to a single pair?

There exist certain observations which it is possible to interpret as supporting this idea. In 1891 I described[8] for a teleost (Serranus embryos) a sensory anlage on the side of the head. The reference to these observations in Minot's Human Embryology 1892 is succinct, and indicates the state of our knowledge on this point at the time: "This thickening (the anlage on each side of the head) forms a long shallow furrow, which subsequently divides into three parts, of which the first becomes a sense organ over the gill cleft, the second, the auditory invagination, and the third, the anlage of the sense-organs of the lateral line. This peculiar development confirms the notion that all these organs belong in one series, but the appearance of a continuous thickening as the anlage of them all, has as yet been observed only in this fish, and may not indicate a corresponding ancestral condition. Unfortu-

[5] Die Segmental-organe der Capitelliden. Mitt. a. d. Zool. Sta. zu Neapel, 1879.

[6] Some New Facts about the Hirudinea. Journ. Morphology, 1889.

[7] The Genus Salpa. Baltimore, 1893.

[8] Embryology of the Sea Bass. Bull. U. S. Fish Comm. Vol. IX.

nately Wilson was unable to make out anything as to the connection of the sensory plate with the ganglia. The sense organ above the gill cleft, although differentiated, is a larval structure only, and disappears in the adult" (quoted from Locy lc. p. 548).

Locy writing on elasmobranch development (1895, lc.) goes on to show the advance of our knowledge in this matter—"A quite similar condition is now known to obtain in some elasmobranch forms. Mitrophanow in 1890 published a preliminary report of his observations on the lateral line of Acanthias and other elasmobranchs. In 1893 he published a full report of the same, illustrated by many figures. He describes a continuous thickening of the epidermis along the sides of the head, embracing the territory of the roots of the seventh to tenth nerves. From this thickening there is separated the material for the auditory saucer, the branchial sense-organs, and the beginning of the lateral line. My observations on this region in Squalus agree with those of Mitrophanow." Locy's observations are briefly described further on in his paper (p. 517), the author mentioning that "a consideration of the so-called branchial sense-organs and their ganglia is reserved to be published later."

The discovery that the common anlage was not a peculiar feature of a teleost species, but existed in widely different Ichthyopsida (Mitrophanow[9] describes the anlage not only for selachians, but for teleosts, cyclostomes, and amphibia as well), indicated that the point was one worth following up.

The Serranus egg is a small, pelagic egg. In it the common anlage is more sharply differentiated from the general ectoderm, than in the selachian and cyclostome forms studied by Mitrophanow and Locy. In Serranus the anlage is a furrow, in the latter forms it is a thicken-

[9] Etude embryogénique sur les Sélaciens. Arch. de Zool. exp. et gen 1893.

ing. In the teleost forms studied by Mitrophanow (species not stated) the anlage develops in same way as in Serranus—as a furrow.

The salmon egg is very different from that of Serranus. It is large, and with relatively firm yolk. At my suggestion Mr. J. E. Mattocks undertook the problem of ascertaining in the first place, whether the common anlage existed in the salmon embryo, and if so, what was its character. The result of Mr. Mattocks's work (published in Anat. Anzeiger XIII Bd. Nr. 24), was to show that the common anlage does exist in the salmon; that it is not a furrow, as in Serranus, but a thickened stripe of ectoderm as in selachians; that it divides into three parts, the middle becoming the auditory sac, the posterior the rudiment of the lateral line, and the anterior remaining as a very noticeable thickening situated above the anterior gill clefts. It thus turns out, as might have been expected, that the peculiarly distinct, furrow-like character of the analge in Serranus, is not universal in teleosts. The difference in the character of the anlage between Serranus and Salmo is perhaps associated with the difference in the character of the two eggs. One is small, light, the embryo cosisting of comparatively few cells, the other large, heavy, the embryo relatively massive and of many cells. Without dwelling on this point (which like other similar questions can be cleared up only by an extensive comparative study of closely related forms, aided, where the method is practicable, by intelligently "put" experiments—in this connection see Davenport's very suggestive "Catalogue of the processes concerned in Ontogeny." Bull. Mus. Comp. Zool. Vol. XXVII. No. 6), it is safe to say that comparative embryology lends some support to the generalization that in embryos of the former type invagination or evagination is apt to occur, while in embryos of the latter type the invagination or evagination is frequently represented by solid in-

growths or ontgrowths (i. e. thickenings)—compare for instance the formation of the mesoblast of Amphioxus with that of other vertebrates, the invaginate gastrula of Leucifer with the corresponding stage of such a form as the lobster.

If we suppose (as a basis for further work, rather than for any other purpose) that the common lateral anlage in the ichthyopsidan embryo indicates the presence in the chordate ancestors of a single elongate sense-organ on each side of the head, then what was the character of this organ? Was it a sac (groove), or merely a superficial sensory area? It is worth while often, to put the question, even if the answer is not forthcoming. Certainly the answer is not now at hand. Though merely putting the question calls to mind the cephalic slits of nemerteans, and Hubrecht's ingenious, if not very popular theory of chordate ancestry.

NOTES ON NORTH CAROLINA MINERALS.*

BY J. H. PRATT.

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INTRODUCTORY NOTE.

The contents of this paper are notes on the North Carolina minerals that have been collected during the past few years. Some of these have already been published

*By permission of the Director of the N. C. Geological Survey.

during the past year, and reference is made to this under the head of these minerals.

These notes are intended primarily for a Bulletin on the Mineral Resources of North Carolina, but the more important of these are published as occasion offers.

WELLSITE, A NEW MINERAL.*

Occurence.—This mineral occurs at the Buck Creek (Cullakanee) corundum mine in Clay Co., North Carolina, and was collected by Professor S. L. Penfield and the author during the summer of 1892 while engaged in work on the North Carolina Geological Survey.

The corundum vein in which the mineral is found is composed chiefly of albite feldspar and hornblende, and penetrates a peridotite rock, dunite, near its contact with the gneiss. The peridotite outcrop is one of the largest in the State and has been thoroughly prospected for corundum. At only one of the veins opened was the new mineral found, although a careful search was made for it at all the openings, especially those affording feldspar. No mining has been done at the locality since 1891, but if work is resumed and the veins uncovered, more of the material will undoubtedly be found.

The mineral is found in isolated crystals mostly attached to the feldspar but also to hornblende and corundum, and is intimately associated with chabazite, (see p. 70), which occurs in small transparent rhombohedrons.

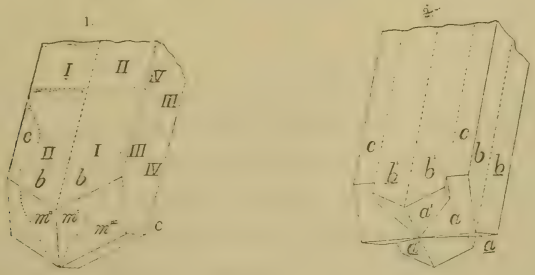
The largest crystals that were observed were not over 1^{mm} in diameter and 2^{mm} in length.

Crystalline form.—The crystals belong to the monoclinic system and they are twinned similarly to those of harmotome and phillipsite. The common habit is shown in fig. 1, which represents a combination of twinning about c, 001 and c, 011. The crystals are practically square prisms, terminated by pyramidal faces, thus imi-

*Am. J. Sci. Vol. III, p. 443, 1897.

tating closely a simple combination of a prism of one order and a pyramid of the other in the tetragonal system. The apparent prismatic faces are formed for the most part by the pinacoid faces, *b*, but the crystals interpenetrate each other somewhat irregularly so that portions of the base *c*, 001, coincide with *b*, fig. 1. The lines of twinning on the pinacoid faces between *b* and *b* twinned are generally regular, while those between *b* and *c* and also those which cross the prism faces *m*, 110 (the apparent pyramid) are generally quite irregular. The *b* faces do not show the striations parallel to the edges *b* and *m*, which, meeting along the twining lines, often reveal the complex nature of such crystals, nor were any reëntrant angles observed parallel to the edges of the apparent prism as are common on phillipsite and harmotome.

Fig. 2 represents another habit of the crystals where *m*, 110 is wanting and *a*, 100 is in combination with *b*, 010. The method of twinning is similar to that already described, but the crystals being terminated by *a*, 100 instead of *m*, 110 show prominent reëntrant angles at their ends. These crystals are very similar to those of harmotome from Bowling near Dumbarton on the Clyde, described by Lacroix.*



The only forms that were observed were *a*, 100; *b*, 010; *c*, 001 and *m*, 110, with *e*, 011 only as twinning plane.

The faces of the crystals are somewhat rounded and

*Bull. de la Soc. Min. de France, No. 4, p. 94, 1885.

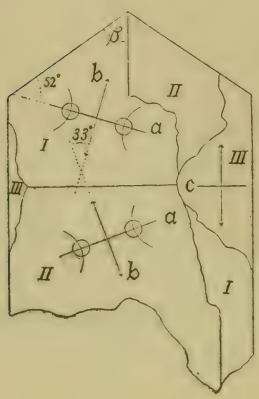
vicinal so that the reflections were not very perfect. The angle of the apparent prism $b\Lambda b$ twinned is approximately 90°. Also the angle $m\Lambda m$ over the twinning plane 011 could be measured only approximately, varying from 0°49′ to 1°25′. The approximate angles are given below, and from those marked with an asterisk the following axial ratio was calculated:

$$a:\overline{b}:c = \cdot 768 : 1 : 1\cdot 245;\ \beta = 53°27' = 001\Lambda 100$$

	Measured	Calculated.
$b\Lambda\underline{b}$, 010Λ010	*90° (over twinning plane)	
$a\Lambda\underline{a}$, 100Λ100	*73°6′ (over twinning plane)	
$b\Lambda m$, 010Λ110	*58°19′	
$c\Lambda a$, 001Λ100	53°27′ = β	
$c\Lambda m$, 001Λ110	60°, 59°45′, 59°57′	59°33′

Physical properties.—The crystals are brittle and show no apparent cleavage. The luster is vitreous. Many of the crystals are colorless and transparent while others are white. The hardness is between 4 and 4·5. The specific gravity taken on a number of separate crystals, by means of the heavy solution, varied between 2·278 and 2·366. This variation was probably due to the difference in the ratio of the barium to the calcium in the different crystals.

3.



A section parallel to the pinacoid faces b, 010, the apparent prism, revealed in polarized light the structure shown in fig. 3. The parts I and I extinguish simultaneously, as also II and II; while portions III, which are parallel to the basal plane, show parallel extinction. The section showed something of a zonal structure, so that the extinction could only be measured approxi-

mately. Using the Bertrand ocular, this was found to be 33° from one pinacoid on to the other over the twinning plane. The axis a makes an angle of 52° with the vertical axis c' in the obtuse angle β.

The double refraction is positive and weak. The acute bisectrix c is at right angles to the pinacoid 010, and the divergence of the optical axes is large. 2E probably varies from 120° to 130°, but this could not be measured directly.

Chemical analysis.—The mineral was purified for analysis by means of the heavy solution and that which was used varied in specific gravity from 2·278 to 2·360.

The analyses were made by Mr. H. W. Foote,** who describes the methods used as follows:

"Water was determined by loss on ignition, and silica and alumina by the ordinary methods after fusion with sodium carbonate. The filtrate from the alumina precipitation was evaporated with aqua regia to remove the large excess of ammonium salts and a small amount of ammonium chloride was again added. Calcium, barium and strontium were then precipitated together, with a considerable excess of ammonia and ammonium carbonate, and magnesia was determined in the filtrate. The mixed carbonates were dissolved in hydrochloric acid evaporated to dryness and taken up in about 300^{cc} of water. The method used for separating barium was that recommended by Fresenius.* To the hot solution, a few drops of acetic acid were added and 10^{cc} of a 10 per cent solution of ammonium chromate containing a small amount of dichromate. After standing until the solution became cold, the clear liquid was decanted and the precipitate of barium chromate was washed with a weak chromate solution and with water. The precipitate was

*Zs. Anal. Chem., xxix, 426.

**Of the Chemical Laboratory of the Sheffield Scientific School, New Haven, Conn.

dissolved in 2cc of pure dilute nitric acid, which was then partly neutralized with ammonia. Ammonium acetate was added and 10cc of chromate solution as before, and after standing, the precipitate was filtered on a Gooch crucible and weighed as $BaCrO_4$.

"The filtrate from the barium precipitation was concentrated somewhat, and calcium and the small quantity of strontium precipitated as before. They were ignited and weighed as oxide. Strontium was then separated by treatment with amyl alcohol and determined as sulphate.

"The alkalies were determined by a Smith fusion in the ordinary way."

The results of the analyses are as follows:

	I.	II.	Average.	Ratio.	
SiO_2	43·62	44·11	43·86	·731	= 3·00
Al_2O_3	25·04	24·89	24·96	·244	= 1.00
BaO	5·00	5·15	5.07	·033	
SrO	1·12	1.18	1.15	·011	
CaO	5·76	5·84	5·80	·104	·228= ·93
MgO	0·61	0·62	0.62	·015	
K_2O	3·40		3·40	·036	
Na_2O	1·80		1·80	·029	
H_2O	13·32	13.39	13.35	·742	= 3.04
			100·01		

The ratio of $SiO_2 : Al_2O_3 : RO : H_2O$ is very close to 3 : 1 : 1 : 3, which gives the formula $R''Al_2Si_3O_{10} . 3H_2O$. The ratio of $BaO : CaO : K_2O + Na_2O$ in the above analyses is nearly 1 : 3 : 2 and the theoretical composition calculated for this ratio is given below together with the analysis after substituting for Na_2O its equivalent of K_2O and for MgO and SrO their equivalents respectively of CaO and BaO and then recalculating to 100 per cent.

		Theory for $R''Al_2Si_3O_{10} \cdot 3H_2O$ where R is $\frac{1}{4}$Ba, $\frac{3}{4}$Ca, $\frac{3}{4}$K.
SiO_2	43·12	42·87
Al_2O_3	24·54	24·27
BaO	6·65	6·62
CaO	6·59	7·27
K_2O	5·98	6·10
H_2O	13·12	12·87
	100.00	100·00

Experiments were made to determine at what temperatures the water was driven off, and the results are given in the following table, the mineral being heated in each case until the weight became constant. The last trace of water could only be driven off by heating the mineral over the blast lamp.

	Loss.	
At 100° C	nothing.	
125	1·93	4·33
175	1·48	
200	0·92	
260	2·45	3·69
295	1·24	
Red heat	4·06	5·29
Over blast lamp	0·33	
Total	13·31	

As is seen from the above, about one-third of the water, or one molecule, is given off between 100° and 200°, another third approximately between 200° and 300°, while the remainder is expelled only at an intense heat. This would indicate that the water exists in three different conditions in the molecule. If only that which is expelled below 200° be regarded as water of crystallization, the composition would be $H_4R''Al_2Si_3O_{12} + H_2O$.

That the new mineral would be closely related to the

phillipsite group of the zeolites, was expected from the first on account of its crystalline form, and this relation is very satisfactorily brought out by a comparison of the crystallographic properties and chemical composition.

They all have very nearly the same axial ratios:

	a	: b :	c	
Wellsite	·768	: 1 :	1·245	$\beta=53^\circ\ 27'$
Phillipsite	·70949	: 1 :	1·2563	$\beta=55\ 37$
Harmotome	·70315	: 1 :	1·2310	$\beta=55\ 10$
Stiblite	·76227	: 1 :	1·19401	$\beta=50\ 49\frac{3}{4}$

In their habit and method of twinning, they are also very similar, all the crystals being uniformly penetration twins. This is especially noticeable between the new mineral and phillipsite and harmotome which are common as double twins with c, 001 and c, 011 as twinning planes.

The place of the mineral in the phillipsite group is clearly shown by a comparison of their chemical compositions. Arranged in order of their proportions of silica and water to the bases, we have the following interesting series, in which R represents the bivalent elements:

Wellsite $RAl_2Si_2O_{10}.3H_2O$
Phillipsite $RAl_2Si_4O_{12}.4\frac{1}{2}H_2O$
Harmotome $RAl_2Si_5O_{14}.5H_2O$
Stilbite $RAl_2Si_6O_{16}.6H_2O$

The ratio of $RO:Al_2O_3$ is constant, 1:1, in the series, while the proportions of silica and water have a constant ratio, 1:1, between themselves, except in the case of phillipsite. As there is, however, considerable variation in the analyses of phillipsite, it is not improbable that the ratio of $SiO_2:H_2O$, given as $4:4\frac{1}{2}$, should be in some cases at least, 4:4. The minerals then form a gradual series, increasing in the proportions of SiO_2 and H_2O from wellsite to stilbite.

Fresenius* has shown that this group of minerals may be regarded as a series in which the ratio of $RO:Al_2O_3$ is

*Zs. Kr., III, 42, 1878.

constant, 1 : 1, while the silica and water vary between certain limits. He has assumed as these two limits:

$$RAl_2Si_6O_{16}+6H_2O \text{ and}$$
$$R_2Al_4Si_4O_{16}+6H_2O$$

The first would be a hydrated calcium albite and the last a hydrated anorthite. From a comparison of the wellsite-stilbite series, it seems more probable that the anorthite end would be $RAl_2Si_2O_8+2H_2O$, or doubling this for better comparison with the formula of Fresenius, $R_2Al_4Si_4O_{16}+4H_2O$.

It is not unreasonable to expect that the first or anorthite member of this series may be found in nature and the completed series would then be:

Anorthite limit . . . $RAl_2Si_2O_8+2H_2O$ (not yet identified)
Wellsite $RAl_2Si_3O_{10}+3H_2O$
Phillipsite $RAl_2Si_4O_{12}+4\frac{1}{2}H_2O$ (perhaps $4H_2O$)
Harmotome $RAl_2Si_5O_{14}+5H_2O$
Stilbite $RAl_2Si_6O_{16}+6H_2O$

It is also interesting to note that the formula of the new mineral wellsite is the same as that assigned to edingtonite, but the latter is essentially a barium mineral and being tetragonal shows no crystallographic relations to wellsite.

Pyrognostics.—When heated before the blowpipe, the mineral exfoliates slightly and fuses at 2·5–3 to a white bead, coloring the flame slightly yellow. In the closed tube, water is given off at a low temperature. It is very readily decomposed by hot hydrochloric acid with the separation of silica, but without gelatinization. When the water in the mineral is driven off below 265° C., it is nearly all regained on exposing the mineral to the air. If the water, however, is driven off at a red heat, none is regained by the mineral.

Name.—The name *Wellsite* is given to this mineral in honor of Professor H. L. Wells of the Sheffield Scientific School, Yale University.

CHABAZITE.

Occurrence.—As described on page62, this mineral is intimately associated with the wellsite, at the Buck Creek (Cullakanee) corundum mine in Clay Co., occurring as a mass of small crystals coating the feldspar, hornblende and corundum. Thus far this mineral has been found only at the large open cut on the eastside of Buck Creek, just northwest of the shaft.

The crystals are transparent to white and very small, no crystal being found that measured over one millimeter in diameter.

The only form observed on any of these crystals was the unit rhombohedron, 1011, which occurs as simple crystals and also as penetration-twins, with c, as the twinning axis.

Chemical analysis.—In obtaining material for analysis, the crystals of the chabazite and wellsite, freed as far as practicable from the feldspar and hornblende were crushed and sifted to a uniform grain. By means of the heavy solution, the chabazite was separated from the wellsite and also from any feldspar or hornblende that may have been attached to them. All of the chabazite floated, when the specific gravity of the solution was 2.278, while the wellsite and heavier minerals sank to the bottom of the separatory funnel. These were drawn off and the solution diluted to a specific gravity of 2.244, but only a small per cent. of the mineral sank. This being drawn off, the solution was further diluted to a specific gravity of 2.203, when nearly half of the remaining mineral sank. This was removed and saved for analysis, (II, below) and the solution again diluted. When the specific gravity had been lowered to 2.147, all, but a small amount of the mineral came down, and this was saved for analysis. (I) A preliminary experiment had been made with the crystals of the chabazite and these were found to vary considerably in specific gravity.

The mineral was analyzed by Dr. Chas. Baskerville* with the following results:

	I				II			
	Sp. Gr. 2·147-2·203	Ratio			Sp. Gr. 2·203-2·244	Ratio		
SiO_2	45·08	·751		= 3·79	46·15	·769		=3·79
Al_2O_3	19·68	·193		= 1.00	20·74	·203		=1.00
FeO	2·00	·028			2.00	·028		
CaO	7·22	·129	·163	= ·84	6·92	·124	·158	= ·77
BaO	·18	·001			·24	·001		
MgO	·23	.005			·22	·005		
K_2O	4·34	·064	·100	= ·50	4·10	·043	·097	= ·47
Na_2O	3·35	·054			3·35	·054		
H_2O	18.00	1·000		= 5·02	16·30	.905		=4·46
	100·08				100·02			

The ratio of $Al_2O_3 : SiO_2 : H_2O$ is near to 1 : 4 : 5 and $Al_2O_3 : (R''.K_2.Na_2)O$ is close to 4 : 5.

Usually in the composition of the chabazites the ratio of $Al_2O_3 : (Ca . K_2 . Na_2)O$ is near to 1 : 1. In the present analysis, no attempt was made to separate any strontium present from the calcium. As a small amount of this element would cause considerable variation in the per cent of CaO, this would readily account for the excess of this oxide in the analysis.

The composition of the chabazite has always been somewhat uncertain as there is often a wide varation in the analyses of specimens from the same locality. The hypothesis advanced by Streng,† that the chabazite is an isomorphous mixture of

$$\left\{ \begin{array}{l} m(CaNa_2)Al_2Si_2O_8 + 4H_2O \\ n(CaNa_2)Al_2Si_6O_{16} + 8H_2O. \end{array} \right.$$

explains satisfactorily the variations observed in this

*Of the Chemical Laboratory, N. C. Geological Survey.

†Ber. Oberhess. Ges. 16, 74, 1877 and Dana Mineralogy, sixth edition, 1892, p. 591.

mineral. This is analogous to the composition of the albite–anorthite feldspars.

The approximate ratios deduced from the above analyses, of $SiO_2 : Al_2O_3 : (Ca.Na_2)O : H_2O = 4 : 1 : 1 : 5$, would give for the formula of this chabazite $m : n$, but with a low amount of water.

The variation in and the high specific gravity of the mineral is without doubt due to the varying proportions of barium and strontium in the molecule.

The occurence of the chabazite at Buck Creek is interesting as being the only known locality of this mineral in North Carolina.

ANORTHITE.*

The occurrence of this feldspar at Buck Creek, Clay Co., N. C., has been described by J. V. Lewis.** The mineral forms with olivine a mass of forellenstin (troctolite) rock, outcropping over an area of about two acres, at the extreme eastern border of the peridotite outcrop. The particles of feldspar vary in size from that of a pea to some nodules that were an inch and a half long by three-quarters of an inch broad and are separated from the olivine by a zone of fibrous silicates, composed partly of enstatite.

The two cleavages are well developed in all the specimens of the mineral and in many of these the striations on the basal cleavage are very distinct.

The feldspar has suffered some kaolinization but the interior of the larger nodules is apparently free from all decomposition. By means of the heavy solution a product was obtained for analysis that varied in specific gravity from 2·6995 to 2·7440.

*Am. J. Sci. Vol. V, 1898, p. 128.

**N. C. Geological Survey, Bulletin 11, p. 24.

The results of the analysis made by Dr. Chas. Baskerville* are as follows:

		Ratio.		
SiO_2	44·05	·734		2·23
Al_2O_3	30·87	·302		·92
FeO	·84	·011		
CaO	17·30	·308	·328	1·00
MgO	·36	·09		
Na_2O	3·65	·057		
K_2O	·83	·009		
Moisture	·35			
Loss on ignition	1·60			
	99·85			

The ratio of $SiO_2 : Al_2O_3 : CaO$, is near to 2 : 1 : 1, which identifies the feldspar as an anorthite.

With the exception of a small amount of this mineral found at Shooting Creek, Clay Co., under similiar conditions, this is the only occurrence of anorthite in this State.

ANTHOPHYLLITE.

In 1890 Prof. S. L. Penfield† described this mineral which was reported as having come from the Jenks coumdum mine near Franklin, Macon Co., N. C.

During the summer of 1892, while engaged with the North Carolina Geological Survey, Prof. Penfield and the author visited an outcrop of dunite rock near Bakersville, Mitchell Co. On breaking open one of the loose boulders of decomposed dunite rock, *anthophyllite* was exposed, which Prof. Penfield at once recognized as identical with the specimen he had described.

As there has been no mention of the correct locality of

* Of the Chemical Laboratory N. C. Geological Survey.

†Am. J. Sci. XL, 1890, p. 394.

the anthophyllite and as this name is often applied to an enstatite occurring at the corumdum mine, it has been thought that a description of the occurrence of these two minerals would be of interest.

At the Woody place two and a half miles south of Bakersville on the Marion road, there is a large outcrop of dunite rock extending from near the road to the top of the hill, a lenticular mass about 600 by 300 feet. The hillside, where it occurs, is quite barren and thickly scattered with loose fragments and boulders of the altered dunite. The outcrop has been carefully examined but the anthophyllite has only been found in the boulders. The mineral occurs in prismatic crystals imbedded in penninite. Nearly all the crystals are seamed and cracked while those near the outer part of the boulders are somewhat decomposed and stained a dirty brown. The purest crystals are transparent, and vary from pale clove brown to a flesh color.

The crystals measure from 2^{mm} to 6^{mm} in the widest diameter and in length, some were found that were over three centimeters.

A great many crystals were examined but no terminated ones were observed. The unit prism, 110, occurring alone, or in combination with the brachy pinacoid, 010, were the only forms observed.

Although the boulders containing the anthophyllite are composed almost always of this mineral and penninite, there are other minerals, resulting from the alternation of the chrysolite, which occur at this locality. These are magnetite in perfect octahedrons 1^{mm} in diameter, green actinolite, chalcedony, druzy quartz, talc, serpentine and genthite. Chromite occurs in grains in the chrysolite.

An analysis of the anthophyllite by Dr. Baskerville is given below, together with the results obtained by Prof. Penfield.*

	I (Baskerville).	II (Penfield).
SiO_2	56.40	57.98
Al_2O_3	1.15	.63
FeO	11.40	10.39
MnO	- - -	.31
MgO	28.68	28.69
CaO	.50	.20
H_2O	1.63	1.67
Loss at 100°	- - -	.12
	99.76	99.99

The two analyses are very similar, and confirm Prof. Penfield's conclusion that the specimen described by him was from the Bakersville locality.

One specimen of a true anthophyllite was found at Corundum Hill by Prof. Penfield; but this was more fibrous and not of such good quality as that from the Bakersville locality.

ENSTATITE.

The enstatite from Corundum Hill that is commonly called anthophyllite, occurs as a rock composed of a mass of interlocking bladed grayish crystals of the mineral. The rock is very tough and tenacious and forms a perfectly continuous mass with the dunite. The outcrop of the dunite at Corundum Hill is very similar to that near Bakersville. The hill of nearly ten acres in extent ha the dunite exposed over nearly its entire surface, and the enstatite is found at the lower south end of the outcrop in the zone of alteration products developed near the contact of the dunite with the hornblende gneiss.

*Am. J. Sci. XL, 1890, p. 396.

The analysis of this mineral by Dr. Baskerville* is as follows:

		Ratio	
SiO_2	51.64	.861	
Al_2O_3	.12	.001	
FeO	9.28	.129	.943
MnO	.56	.008	
MgO	31.93	.798	
CaO	.45	.008	
H_2O	5.45	.303	
	99.43		

It is evident from the amount of H_2O found, that the material analyzed was not pure, but was probably a mixture of the enstatite with serpentine and talc.

As is shown by the calculations below, the ratio in the above analysis would be satisfied by a mixture of 44.5 per cent. enstatite, 35 per cent. serpentine and 20.5 per cent. talc. The analysis is also given below after substituting for MnO and CaO their equivalents of MgO, deducting Al_2O_3 and recalculating to 100 per cent.

	44.5 per cent. Enstatite.	Ratio.	35 per cent. Serpentine.	Ratio.	20 per cent. Talc.	Ratio.	Total.	Recalculated Analysis.
SiO_2	24 42	.407	14.87	.246	13.02	.217	—52.31	52,19
FeO	7.58	.105	1.84	.025	- - -		— 9.42	9.39
MgO	12.50	.312	13.83	.346	6.51	.163	—32.84	32.91
H_2O	- - -		4.46	.246	.97	.054	— 5.43	5.51
	44.50		35.00		20.50		100.00	100.00

ENSTATITE (BRONZITE.)

The occurence of this mineral in any considerable amount in North Carolina was first mentioned by Dr. G. H. Williams** who described specimens of a bronzite-diopside rock, to which he gave the name websterite.

*N. C. Geol. Survey, Bull. 11, p. 27.

**American Geologist VI, pp. 43-4, 1890.

†J. V. Lewis N. C. Geol. Survey, Bull. 11. p. 27.

These specimens were collected near Webster, Jackson Co., by Mr. Geo. P. Merrill of the U. S. National Museum.

On the road from Webster, following up the Tuckaseegee river valley and about one half mile from the town, a mass of dunite* is exposed for over 1500 feet on a hillside facing the river. In the midst of this outcrop, the websterite occupies a width of nearly 300 feet. This outcrop of dunite is very similar to that near Bakersville and at Coumdum Hill, described above.

This rock as described by Williams,* is composed entirely of bronzite and an emerald-green diopside. The ground mass of this rock is composed of the brilliant green grains of the diopside through which rounded crystals of the pale brown bronzite are disseminated. The relative amount of the bronzite is variable as it shows a tendency to concentrate in nests or bands.

Lewis** speaks of this rock as a compact granular rock closely resembling the dunite with which it is associated.

Near the north end of the dunite outcrop, at the side of the road, boulders were observed, which when broken open were found to be composed almost entirely of bronzite. Besides the boulders a mass of the same rock was observed apparently *in situ*.

The bronzite composing this rock is of a resinous brown color, and of a bronze like luster, even on the unaltered surfaces. On the cleavage surface the luster is decidely pearly. No distinct crystals were observed, the specimens being a mass of interlocking crystals making a very tough rock similiar to the enstatite described above. In most of the specimens, the crystals were so interlocked that no crystal outline of these could be distinguished. In a few of the specimens the crystals were much larger

*American Geologist VI, pp. 43—4, 1890.

**N. C. Geol. Survey Bull. 11. p. 27.

in their development and their outline could readily be detected. Some of the crystals measured 2^{cm} in the direction of the *b*, axis.

Associated with the bronzite is the emerald-green diopside mentioned by Williams, which is sparinglg scattered through the rock in very small, clear, green grains.

While the websterite is composed of a base of diopside grains with the rather large rounded crystals of the bronzite penetrating through it, the bronzite rock is essentially interlocking prismatic crystals of the bronzite with a few grains of the diopside disseminated through it. This rock, also, does not show any of the granular character of the websterite; but on the contrary it is very compact and tough.

The material for analysis was hand picked and that selected showed no impurities or decomposition when examined with the magnifying glass.

The results of the analysis by Dr. Baskerville are given below:

		Ratio		
SiO_2	53·62	·894		=1.
Al_2O_3	·97	·009	·012	
Cr_2O_3	·50	·003		
FeO	9·06	·125	·994	=1·11
CaO	1·75	·031		
MgO	33·53	·838		
H_2O	·19			
	99·62			

In the above analysis the ratio of the bivalent oxides to silicia is close to 1 : 1, and of ferrous oxide to magnesia and lime is very near to 1 : 7; this would give the formula $(MgFe)SiO_3$ with Mg : Fe=7 : 1. Assuming that the Al_2O_3 and Cr_2O_3 belong to spinel and deducting RO sufficient to combine with them, the analysis, after substituting for CaO its equivalent of MgO and recalculating to

100 per cent. is given below together with the theoretical composition calculated for this formula.

	Found	Theory for $(MgFe)SiO_3$; Mg : Fe=7 : 1
SiO_2	55·35	57·69
FeO	9·14	8·65
MgO.....	35·51	33·66
	100·00	100·00

The name bronzite is very appropriate to this Webster enstatite, for the luster is of a decided bronze-like character throughout the entire mass and is undoubtedly not of a secondary origin, but is the natural luster of this mineral. A similiar bronzite, showing the same decided bronze-like luster has been found at the Buck Creek, (Cullakanee,) corundum mine in Clay county.

EMERALD BERYL.

Although the beryl is a very common accessory mineral, in granite veins, especially those of a pegmatitic character, it is not common to find the deep emerald green variety. The earliest report of the emerald in North Carolina is 1880, by W. E. Hidden* who describes the occurrence in Sharpes Township, Alexander Co. where it is found associated with the emerald green hiddenite.

The occurence of the emerald in Mitchell Co. has been known since 1886, though but little work has been done to develope the locality and to estimate its economic value. The mineral is found on the divide between Brush and Crabtree Creeks about four miles south of Spruce Pine, post office.

The vein carrying the beryl is of a pegmatitic character consisting chiefly of quartz and an albite feldspar, with

*Elisha Mitchel Scientific Society. 1880.

tourmaline, garnet and the beryl as accessory minerals. The country rock is a gneiss and biotite schist.

The emerald beryl has the characteristic green color of the gem and some of the crystals are transparent. They all have the hexagonal prism well developed, but none were observed that showed any terminations. The crystals vary in size from less than a millimeter up to eight millimeters in diameter. They are found imbedded in the quartz, feldspar and biotite schist, but are for the most part near the contact of the vein with the schist. The most transparent and deepest green crystals observed were either entirely surrounded by the schist or close to the contact. Those in the quartz were usually more transparent than those found imbedded in the feldspar. The color of the crystals varies with their location in the vein, those nearest the schist being of the emerald variety, while those farther away are pale green or yellow.

The yellow or cream colored beryls are very abundant though the vein. The crystals vary considerably in size, from those hardly 2^{mm} in diameter to one that measured 17^{cm}.

The locality as yet has not been developed sufficiently to demonstrate whether it will warrent its being worked for gems. Both Col. Rorison of Bakersville, and Capt. Isaac English of Spruce Pine report that crystals have been found from which good gems were cut.

GRASS GREEN CYANITE.*

The mineral to be described occurs on the farm of Tiel Young, near North Toe River, Yancey Co., North Carolina, a few miles from Spruce Pine, Mitchell Co.

Some exceptionally large crystals of a grass-green color were obtained by the author during the summer of

*Am. J. Sci. Vol. V, 1898, p. 126.

1896 from Mr. M. Alexander, a jeweler in Asheville. After some difficulty the occurrence was located, during the summer of 1897, and the locality has been thoroughly worked by Geo. L. English & Co. of New York, with the result that many good crystals of the cyanite have been obtained.

The mineral occurs in a decomposed mica schist from which the single crystals are easily separated. The crystals are often intergrown and masses of these were obtained as large as one's two fists. All of the crystals found were of a rich grass-green color and many were quite transparent. A few of the crystals showed a deep blue center with the grass-green margins. The crystals vary in size from $1\times\cdot7^{cm}$ to $3\cdot2\times6^{cm}$; a few coarser ones were observed that were considerably larger. The finest crystal that has been found at this locality measured $5\cdot8\times2\cdot2\times1\cdot8^{cm}$ and was perfectly transparent at one end for about 2^{cm}. The three pinacoids were the only faces observed on this crystal and these were evenly and well developed. This crystal is now in the Brush Collection at New Haven, Conn. The faces are generally smooth, giving fair reflections of the signal on the reflecting goniometer.

The forms observed on these crystals are as follows.

c, 001	*a*, 100	*M*, $1\bar{1}0$	
b, 010	*m*, 110	Q, 120	*t*, 520

The face 520 is apparently a new one for cyanite. The three pinacoids were the only faces observed on the majority of the crystals, some of which were doubly terminated. After a very careful examination of the terminatio s, they were decided to be real basal planes and not cleavage surfaces. On one of the crystals, all of the faces observed were developed.

The following table shows the identification of the forms by calculated and measured angles. In obtaining the calculated angles the elements given in Dana's Min-

eralogy (1892), deduced from Rath's measurements* on Greiner crystals, have been used.

$a:b:c = 0{\cdot}89938:1:0{\cdot}70896$; $\alpha = 90°5\frac{1}{2}'$; $\beta = 101°2\frac{1}{2}'$; $\gamma = 105°44\frac{1}{2}'$

	Calculated.	Measured.
$a \wedge m$, $100 \wedge 110$	34° 17′	34° 17′ ; 34° 20′;
$a \wedge M$, $100 \wedge 1\bar{1}0$	48 18	48 43 ; 48 41; 48° 45′
$a \wedge Q$, $100 \wedge 120$	48 43	48 50
$a \wedge l$, $100 \wedge 520$	17 9	17 13
$a \wedge b$, $100 \wedge 010$	73 56	73 40 ; 73 38; 73 42
$b \wedge M$, $010 \wedge 1\bar{1}0$	57 46	57 41

The specific gravity is 3·64 and was determined upon several different samples. Pleochroisim is very strong.

Iron and chromium were very carefully tested for, but no trace of either was observed in the analysis, which showed only the presence of alumina and silica.

Crystallized cyanite is usually in long bladed crystals without terminations, the best crystals having been found at St. Gothard in Switzerland and on Mt. Greiner in Tyrol. These crystals of a blue and blueish white color, are often transparent but are seldom over a few millimeters wide.

This new occurrence of the cyanite is not only of interest on account of the deep green color of the mineral but also on account of the exceptional size and development of the crystals.

Pale green cyanite has been obtained from a number of localities and it has also been found in the vicinity of the green cyanite locality on the farm of Isaac English of Spruce Pine, Mitchell Co., imbedded in an undecomposed mica schist. Another occurrence that is worthy of note is that of Graves Mt., Georgia. At this locality thin small plates of the pale green cyanite are associated with well crystallized rutile.

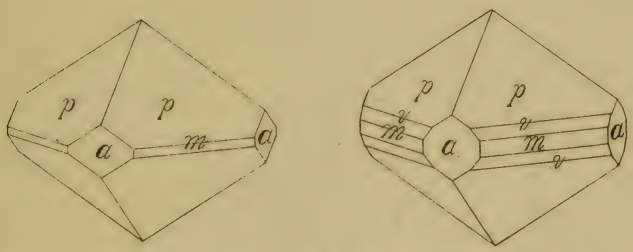
*Zs. Kr., v, 17, 1880.

ZIRCON.*

Some specimens of zircon crystals were obtained of Messrs. Geo L. English & Co., from New Stirling, Iredell Co., North Carolina, and on account of their size and development it has been thought a description of them would be of interest.

The crystals are all very similar in their habit, in which the unit pyramid is strongly developed while the prisms faces are short, figs. 4 and 5. Fig. 4 represents the majority of the crystals, where the prism of the first order is only slightly developed, at times being hardly perceptible. Those represented by fig. 5 are similar in their habit to some zircon crystals described by the au-

4. 5.



thor from the townships of Dungannon and Faraday, Ontario.†

The following forms were observed on these crystals:

a, 100; *m*, 110; *p*, 111; *v*, 221; *x*, 311.

The face *x*, 311 was only observed on a very few of the crystals and was but slightly developed. The crystals are all well developed with smooth faces, making them well adapted for measurement on the reflecting goniometer. Although the author had no reflecting goniometer at hand, the faces were readily identified by means of the contact goniometer.

The crystals vary in size from 1^{cm} to $2{\cdot}5^{cm}$ in diameter and are of a reddish-brown color.

*Am. J. Sci. Vol. V, 1898, p. 127.

†Am. Jour. Sci., vol., xlviii, p. 215, 1894.

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FIFTEENTH YEAR—PART ONE.

1898.

THE NATURE OF THE CHANGE FROM VIOLET TO GREEN IN SOLUTIONS OF CHROMIUM SALTS.

By F. P. Venable and F. W. Miller.

It is a well-known fact that solutions of certain chromium salts which are violet in color become green on heating. This has been especially noticed in the case of the chrome-alums and of the sulphate, but is also true of the nitrate, chloride, and acetate, in fact, of all the soluble compounds of chromium. A reverse reaction also takes place and all of these solutions made green by heating become violet again on standing, the nitrate, chloride, and acetate very rapidly, the sulphate and alums slowly, and often only after prolonged standing. It is quite reasonable to suppose that these changes are caused by similar reactions in the case of various salts, and that there is one explanation for all.

A large number of explanations have been offered by various investigators. In fact it is surprising to find how many have been drawn to investigate these changes and what an amount of work has been done upon them. Perhaps the difficult nature of the problem has been the great source of attraction. Fischer[1] and Jacquelain[2]

1 Kastner's *Archiv.*, 14, 164.

2 *Compt. rend.*, 24, 439.

have attributed these changes to a separation of the chromium sulphate from the alkaline sulphate; Berzelius[1] and Fremy[2] assigned as the cause of the changes the formation of a basic sulphate; Recoura and Whitney[3] and Dougal[4] have considered the true cause to be the formation of a chrom-sulphuric acid; Schrötter[5] suggested a partial dehydration, and Etard[6] also thought the change due to an alteration in hydration; Roscoe and Schorlemmer[7] regarded the green solutions as containing mixtures of basic and acid salts; Loewel[8] advanced the theory of an isomeric change.

It is quite manifest that any theory like that of Fischer and Jacquelain, based upon an examination of the alums alone, is quite inadequate. It is further evident that any phenomenon which has aroused so great a variety of speculations as this must be considered very carefully with due weighing of every known fact. These facts are numerous and important.

HOW THE CHANGE MAY BE BROUGHT ABOUT.

Chrome-alum is soluble in six parts of water; the violet solution suffers the alum slowly to crystallize out unchanged by spontaneous evaporation; but if heated to between 50° and 75° it turns green and, according to the extent of decomposition, either deposits on evaporation a brilliant, green, amorphous, difficultly soluble mass, or "yields crystals of sulphate of potash, leaving green sulphate of chromic oxide in solution."[9]

Schrötter says the change takes place at 65°–70°. He

[1] *Ann. Phys. Chem.*, 61, 1.
[2] *Compt. rend.*, 47, 883.
[3] *Ztschr. phys. Chem.*, *1896*, 20, 40.
[4] *J. Chem. Soc.*, Lond., *1896*, 69, 1526.
[5] Pogg. *Ann.*, 53, 513.
[6] *Compt. rend.*, 84, 1090.
[7] Treatise on Chemistry, First Edition, Vol. II, Pt. II, 163.
[8] *J. d. Pharm.* (3), 7, 321.
[9] Fischer, cited in Gmelin: Handbuch, *1850*, IV, 149.

further states that the crystals of potassium sulphate separate only from a highly concentrated solution and in small quantity. Sprung has shown, in experiments to be quoted later, that the change begins at a temperature under 30°.

We have repeatedly attempted to secure the separation of crystals of potassium sulphate as described by Fischer and Schrötter, but without success. The exact conditions are clearly difficult to hit upon, if such a separation is at all possible.

Alkaline hydroxides and carbonates, according to van Cleeff,[1] turn violet solutions of the alums green, and Etard[2] has shown that they bring about the same change in solutions of the normal sulphate. Sulphuric acid, phosphorus trichloride, and nitric acid, according to Etard, bring about the same change, but Otto[3] says that sulphuric acid does not turn solutions of the alum green if rise of temperature is prevented. Schrötter says that nitric acid turns green solutions of chromium sulphate blue again.

Our experiments along this line resulted as follows: First as to the action of acids. Hydrochloric acid had no action upon either violet or green solutions, nor does it apparently have any influence upon the change from one to the other on heating. Sulphuric acid brought about no change in either in the cold, but has a retarding influence upon the change on heating. This was so marked in one or two experiments that it was thought the change would be entirely prevented. Nitric acid had no appreciable immediate effect upon either in the cold. On heating with the violet the retarding action was greater than when sulphuric acid was used, and the solution resumed its violet color on cooling. Acetic acid had

1 *J. prakt. Chem.* (2), 23, 58.

2 *Compt. rend.*, 84, 1090.

3 Graham-Otto, 4 Aufl., 3, 113.

apparently no influence. As to the action of alkalies, sodium or potassium, or ammonium hydroxide, or the carbonates, readily turned the violet solutions green. They had no action upon green solutions.

CHANGES IN PHYSICAL PROPERTIES.

In the case of chromic sulphate, Sprung[1] has shown that the violet solution with about twenty-four per cent. of the salt has the specific gravity 1.1619, while the green is 1.1486. So too with the alum there is an increase of volume, which has been noticed by Siewert and also by Mohr,[2] and a decrease of volume is observed as the green solution reverts to the violet. Lecoq de Boisbaudran[3] has also observed these changes, noting that they are independent of the concentration of the solution, the presence of crystals, or whether the vessel is open or closed. The changes in density can be reckoned from his dilatometric observations. Dougal[4] has shown that the alteration in density of even a dilute solution of chrome-alum, after boiling, may readily be detected by a specific gravity bottle. In this manner, one, two and a half, and five per cent. solutions were experimented upon. The actual amount of change depended upon the duration of the heating and the length of time which had elapsed since the green solution had been prepared. The violet solutions became specifically lighter when changed to green by boiling. The transformation is accompanied therefore by expansion.

According to Sprung the violet and green solutions show a difference in internal friction or viscosity. The ratios of diffusion out of capillaries at temperatures 10° 20°, 30°, 40°, 50°, of the green to the violet were as 100

[1] *N. Arch. ph. nat.*, 53, 112.
[2] *Ber. d. chem. Ges.*, *4*, 318.
[3] *Compt. rend.*, 79, 1491.
[4] *J. Chem. Soc.* Lond., *1896*, 69, 1597.

to 60.70 ; to 67.77 ; to 68.74 ; to 70.79 ; to 75.72. From this it is seen that the change begins at less than 30°, and from this arises the observation that has been made that the solution of the alum turns somewhat green at ordinary temperatures.

The diffusion of these solutions has also been carefully studied with a view to throwing light upon this puzzling problem.

With regard to the sulphate it has been shown by van Cleeff[1] that green solutions on being dialyzed yield dialysates containing a larger proportion of acids. This had been repeatedly investigated in the case of the alum. Thus van Cleeff has found that in the dialysis of the green solution of the alum, relatively more sulphuric acid goes into the dialysate than when the violet solution is dialyzed. Dougal[2] has also carried out careful experiments along this line. Time, temperature, strength of the dialysate, amount of initial change, amount of retrogression, all affected the results, and little beyond the facts stated above could be deduced from them. The experiments were made upon solutions containing one per cent. of the alum. While the author states that no comparison could justly be made between the experiments, it may be noted that the ratio of increase in acidity was fairly regular and ranged between one-seventh and one-sixth.

A few experiments were undertaken upon the dialysis of the alum before Dougal's experiments were known to us. They were not pushed to completion when these latter became known, especially as there seemed little chance of their throwing much light upon the nature of the change.

CHANGES IN CHEMICAL PROPERTIES.

One of the most singular changes in chemical proper-

[1] *J. prakt. Chem.* (2), 23, 58.
[2] *J. Chem. Soc.* Lond., *1896*, 69, 1527.

ties is that noted in the action of the sulphate or alum, before and after heating, upon solutions of barium or lead salts. This was first observed by Loewel[1] and was studied by Favre and Valson.[2] A violet solution on being treated in the cold with a solution of barium chloride, yields practically all of its sulphuric acid as barium sulphate. A cold green solution forms a precipitate slowly, and even after a number of hours the precipitation is far from complete. On boiling, all of the sulphuric acid will be precipitated. Favre and Valson found that only one-third of the sulphuric acid present in the original chromic sulphate was precipitated in the cold by the barium chloride.

Our own experiments upon this point were as follows: A weighed amount of the pure alum was dissolved and the solution made up to a definite quantity. Two aliquot portions were taken, one of which was heated for half an hour and allowed to cool. Then both portions were precipitated with an excess of barium chloride. It was found impossible to filter these immediately with asbestos felts or the best filter-paper. They were therefore allowed to stand about twenty-four hours. This very long standing probably changed the conditions somewhat, but we were unable to avoid it. Still the results would confirm the observations of Favre and Valson. The prolonged standing also showed that it was not merely a delayed precipitation, but one partially prevented.

	I.	II.
Percentage of SO_3 in alum is 32.06		
Percentage of SO_3 in alum, violet solution precipitated cold	30.44	30.19
Percentage of SO_3 in alum, green solution heated one-half hour	22.78	22.33
Percentage of SO_3 in alum, green solution heated one hour	22.87	21.83

[1] *J. Pharm.* (3), 4, 32.
[2] *Compt. rend.*, 77, 803.

These experiments were upon solutions containing one gram to 100 cc. A solution twice as strong was next taken:

	I.	II.
Percentage in violet solution precipitated cold	28.88	31.80
Percentage in green solution (heated one hour) precipitated cold	19.55	21.47

Again a solution containing 0.5 gram to the 100 cc. was taken.

Percentage in violet solution precipitated cold	28.30
Percentage in green solution (heated one hour) precipitated cold	23.00

The difficulties of washing and filtering barium sulphate precipitated in this manner account in part for the lack of agreement between the analyses, but two things are evident; first, that all the sulphuric acid is not precipitated from either violet or green solutions in the cold, and, secondly, that a short boiling effects such a change that only two-thirds of the sulphuric acid is precipitated by barium chloride in the cold. The amount not precipitated ranged from 9.06 to 13.51 per cent.

Many observations have been recorded as to the acidity of the violet and green solutions of the alum. Recoura[1] has stated that the vapors coming from a solution at 100° are acid, while the solid salt at the same temperature does not lose any acid. He further maintains that the green solution, left after the heating, contains a considerable amount of free acid. He made use of the heat of neutralization as a means of measuring the degree of acidity. A known amount of soda was added to the liquid and the heat liberated was measured. In so far as this corresponds with the heat liberated by the neutralization of free sulphuric acid in the same degree of dilution, he concluded that he was dealing with free acid. According to his

1 *Compt. rend.*, 112, 1440.
2 *Ann. Phys. Chem.* (3) 61, 218.

experiments there was one-half of an equivalent of sulphuric acid for every equivalent of chromium sulphate.

It was Kruger[1] who first attempted to show in 1844 the presence of free sulphuric acid in the green solution. He thought this was proved by the acidity of the layer of alcohol poured over the green solution.

Baubigny and Pechard[2] have shown that the alum has always an acid reaction even after purification by means of alcohol. Further they regarded the following experiment as proving a partial dissociation of the salt. To twenty cc. of a saturated solution of the alum, three-tenths gram of ammonia gas was added, and, after shaking, the liquid was neutral to methyl orange; after some time the liquid which had become green on the addition of the ammonia, yielded violet crystals with strong acid-reaction and the mother-liquor had become acid to methyl orange.

Whitney[1] has also attempted to prove the presence of acid by physical methods. Sodium hydroxide and barium hydroxide respectively were added to the green solution. The addition of a base must lower the conductivity of the solution as long as free sulphuric acid is being neutralized. He found the minimum when he had added one-sixth of an equivalent of sodium hydroxide to the chromium sulphate, or one-third of an equivalent of barium hydroxide. No explanation was given of the variation in the results. He also claimed to have proved the presence of free acid by the catalysis of methyl acetate. Lastly, the inverting action of green solutions of chromium chloride, acetate, nitrate, and sulphate was tried upon sugar solutions. He came to the conclusion that in the case of the chloride and nitrate, two-thirds of the acid was set free on boiling; of the acetate more than two-thirds, and of the sulphate less than one third. In our own experiments as to the relative

1 *Compt. rend.*, 115, 604.
2 *Ztschr. phys. Chem.*, 1896, 20, 40.

acidity of the violet and green solutions, it was seen that both solutions were acid. We tried a large number of the usual indicators, but the violet and green colors of the solutions interfered too much to give any results with them which could be regarded as at all satisfactory. It was found that fair results could be obtained by using a decinormal solution of ammonia and noting the first appearance of a permanent precipitate.

	Tenth-normal ammonia. cc.
One gram in 100 cc. cold required	27.5
" " " " " boiled one-half hour	27.6
" " " " " " one hour	26.5
" " " " " " two hours	26.5

During the boiling, the water evaporated was repeatedly restored. Unless this was done a little acid was lost, and even with this precaution there was a small loss, and this may explain the acidity of the vapors coming off at at 100° as observed by Recoaru.

The experiments therefore agree with those of Baubigny and Pechard, but are at variance with the conclusions of the other authors mentioned. We think the experimental data of these authors do not afford sufficient and satisfactory evidence to serve as a basis for their conclusions that free sulphuric acid exists in the solution. The methods adopted are very indirect and the results capable of other explanations.

THE EXISTENCE OF CHROMO-SULPHURIC ACIDS.

Several articles have been published by Recoura[1] upon chromo-sulphuric acids. He claims to have prepared several of these and regards the formation of such bodies as a probable explanation of the change in the green solutions, and others, as Whitney and Dougal, seem to accept his explanation. Recoura thinks there are two isomeric modifications of chromium sulphate; one violet, one green, and also another green sulphate not isomeric,

but basic ($2Cr_2O_3.5SO_3$). These he refers to three conditions of chromic hydroxide: $Cr_2(OH)_6$, precipitated by alkalies from violet chromic salts; $Cr_4O(OH)_{10}$, corresponding to the basic sulphate and non-isolable; $Cr_2O(OH)_4$, precipitated by alkalies from green solutions. Solutions of this latter in acids, he says, are not precipitated by solutions of barium salts. This last statement is not strictly true. Such solutions are partially precipitated by barium salts just as all green solutions are. He assigns to the green sulphate the formula $Cr_2O_3.3SO_3.11H_2O$, which he says has quite a different constitution from that of the violet sulphate. Proofs for this statement he does not give. This isomeric green sulphate, he says, possesses neither the characteristics of a sulphate nor of a chromium salt. One molecule can combine with one molecule of either sulphuric acid or a metallic sulphate. Thus we may have $Cr_2(SO_4)_3.H_2SO_4$, or $Cr_2(SO_4)_3.K_2SO_4$. In these compounds all the sulphuric acid is in a non-precipitable form, he maintains. His crucial experiment is as follows:

"Mix a solution containing one molecule of $Cr_2(SO_3)_4$ with a solution containing one molecule of sulphuric acid or a sulphate. Union is immediate, for barium chloride will now give no precipitate and the solution therefore holds no sulphate. The new radical is unstable, for precipitation is immediate on boiling, or in concentrated solutions or in dilute solutions on standing one-half hour. *It is necessary to work with very dilute solutions, otherwise the radical containing chromium is decomposed.*"

Of course such reasoning would give us these same strange isomeric metal-sulphuric acids in all sulphates, for if they are diluted enough it will take half an hour or more for the precipitate to form with barium chloride.

On such slender basis Recoura builds up a series of salts of a hypothetical chromo-sulphuric acid $(Cr_2.4SO_4)_2$.

1 *Compt. rend.*, 113, 1037; 114, 477; 116, 1367.

He has also prepared a chromo-disulphuric acid, etc., by evaporating solutions of chromium sulphate with two, three, etc., molecules of sulphuric acid, and then heating to 110°–120°. Calvert and Ewart[1] have shown that, on diluting these, they all leave a colloidal $Cr_2(SO_4)_3.H_2SO_4$ upon the septum, the liquid passing through free of chromium. The behavior of these solutions makes it appear probable that the chromo sulphuric acids do not exist in them as such, but are hydrolyzed, forming the colloidal substance, $Cr_2(SO_4)_3.H_2SO_4$, and free sulphuric acid. Our repeated experiments have failed to show the presence of this colloidal body in the ordinary green solutions of the alum or sulphate. A boiled solution of either, even though very concentrated, will pass entirely through an unglazed porcelain suction filter, such as Calvert and Ewart made use of. There seems to be no colloidal body present.

We cannot regard the experiments of Recoura as advancing the subject in any degree. As an explanation of the changes it is by no means satisfactory. Dougal's formula for the reaction causing the change, is even more remarkable and baseless :

$$2[Cr_2(SO_4)_3.K_2SO_4]+H_2O = [Cr_4O(SO_4)_4]SO_4 + 2K_2SO_4+ H_2SO_4.$$

This is not based upon Dougal's own experimonts but is offered as an explanation deduced from the work of Recoura, Whitney, Favre, and Valson.

THE ACTION OF ALCOHOL.

There have been several investigations of the action of alcohol, both upon the sulphate and the alum, with the hope of throwing some light upon the changes under consideration. Traube[2] states that the solid salt is unaffected by boiling alcohol. Schrötter has observed[3] that

1 *Chem. News.* 74, 121.
2 *Hnn. Chem.* (Liebig), 66, 168.
3 Pogg. *Ann.*, 53, 413.

solutions covered with a layer of alcohol become gradually green and the concentrated green solution is not dissolved by alcohol. Of course the first observation does not necessarily connect the alcohol with the change. Alcohol in large amounts precipitates from violet solutions of the sulphate a pale violet colored, crystalline powder, and decolorizes the liquid.[1] This can be used as a mode of purifying the alum.[2] Siewert[3] states that, when the violet sulphate is dissolved in a small amount of water and boiled with alcohol until the crystals formed are again taken up and then precipitated with ether, a green syrup is gotten which consists of $5Cr_2O_3 12SO_3 . xH_2O$ and the mother-liquor contains sulphuric acid in a condition in which it is not precipitated by barium chloride. Krüger[4] states that alcohol precipitates from a green solution of the alum a green oil which solidifies and which contains only two-thirds of the sulphuric acid. Siewert confirms this and says that this substance has approximately the composition $6K_2O.5Cr_2O_3.18SO_3.H_2O$. Krüger mentioned the acidity of the alcohol used in precipitating the green oily liquid and evidently regarded it as withdrawing sulphuric acid from the original salt. He also mentioned the formation of a basic salt, by heating the green solution until it becomes rose-red, which contains half as much acid as the neutral salt and is insoluble in water.

After a careful consideration of the results obtained by others by means of alcohol, it seemed to us quite possible that these might afford a clue to the explanation we were in search of. It was necessary to examine with care the action upon both the violet and the green solutions. Our experiments are therefore given in detail, and it will be

1 Gmelin's Handuch, IV, 127.
2 Baugigny and Pechard: *Loc. cit.*
3 *Ann. Chem.* (Liebig), 125, 97.
4 *Ann. Phys. Chem.*, 61, 318.

seen that they agree in part only with the observations just quoted.

Action on the Violet Solution.—When alcohol was added to the violet solution of alum, fine violet crystals were precipitated, which gave on analysis the following results:

	Calculated for $K_2Cr_2(SO_4)_4.12H_2O$.	Found. I.	II.
Cr	13.32	13.68	13.36
K	9.99	9.80	
SO_4	49.99	48.85	

This may be an old observation that on crystallizing from alcohol the crystals contain only half the usual amount of water, but we have not met with it anywhere. The fact that this very considerable change of hydration effects no change in color nor in the precipitating power of barium chloride, argues against the partial dehydration theory of Schrötter and Etard. It should be added that the precipitation was carried out with absolute alcohol upon concentrated solutions of the alum, was rapid, and the precipitate was immediately removed. There seemed to be two layers of crystals, one of violet crystals (upper) and the other a heliotrope powder. Analysis showed that the composition of both was the same and that the difference was probably one of subdivision. The precipitation is almost complete, as the alcohol shows very little color. From this it is evident that alcohol itself does not materially affect the violet solutions.

Action on the Green Solutions.—Green solutions of the alum were first experimented with. When absolute alcohol is added to concentrated solutions of chrome alum, which have been boiled until green and allowed to cool, a dark green gummy mass separates out after a short time. If the boiling is not sufficiently prolonged there will form afterwards a few violet crystals. The alcohol retains something in solution, as is shown by the green color. This amount retained may be considerable if much water

is present. It would seem then, that alcohol precipitates out the body and makes it available for analysis and examination. If a portion of this green, gummy mass is taken and dissolved in water, it exhibits the same behavior towards barium chloride as has been observed in the green solutions. In one or two cases it was observed that the part remaining dissolved in the alcohol yielded practically all of its sulphuric acid to barium chloride in the cold. The green mass was thoroughly washed with alcohol and dried over sulphuric acid. It also dries to a brittle mass if exposed in thin layers to the atmosphere. It is quite insoluble in alcohol, but soluble in water. A number of preparations of this substance were made and analyzed and the results are in such agreement that one is inclined to believe that the substance is a definite compound.

Fifteen grams of chrome alum were dissolved in 100 cc. water and boiled for one hour to a concentration of fifty cc. This was cooled and precipitated by the addition of 100 cc. of absolute alcohol. The green mass obtained on drying weighed about eight grams. This was carefully analyzed :

	Calculated for $7K_2SO_4.5Cr_2(SO_4)_3Cr_2(OH)_6.4H_2O$.	Found. I.	II.	III.	IV.
Cr	18.07	18.23	18.32	18.02	17.76
K	15.88	15.18	15.63	15.78	
SO_4	61.08	60.55	60.73		60.79

Analysis III and IV were from other preparations, made, however, in a similar manner to that just described. This substance appears to have quite a complicated constitution, and it is not easy to see the part played by the potassium sulphate. It do esnot seem to be a matter of accidental occurrence, however. The important feature is that the salt is a basic one. Siewert gives, as the result of his analysis, $6K_2O.5Cr_2O_3.18SO_3.H_2O$, for which the following percentages would be required : Cr, 18.7 ; K, 16.8 ; SO_4, 61.9. While these percentages differ somewhat from those obtained by us, the agreement is suffi-

cently close to show that the substances examined were practically the same.

On concentrating the liquid poured off from the green gum, it was repeatedly observed that more of the gum was obtained. For instance, in the experiment described where the green mass from fifteen grams weighed about eight grams, a further portion weighing 0.3915 gram was gotten. The analysis of this yielded the following percentages: Cr, 13.66; K, 8.57; and SO_4, 55.45. We could only regard this as a mixture consisting in part of the green basic mass which had not completely separated out. The small amount of material left in solution (less than one-half gram) consisted of a little chromium with sulphuric acid in the ratio of about five to one.

Next the action on chromium sulphate was examined. The chromium sulphate used was in the form of small violet scales or crystals. It was a commercial product and the method of its preparation was unknown to us. An analysis of it gave:

Cr	22.10.
SO_4	44.20.

It is therefore a basic chromate, but we have seen no such body described in the books. It dissolved in water with a green color. Fifteen grams of this dissolved in 100 cc. of water, boiled to a concentration of 50 cc. and precipitated with 100 cc. of alcohol, yielded about ten grams of the green, gummy mass, very similar in appearance to that obtained from the alum, but more soluble in alcohol. In a second experiment twelve grams were taken and treated in the same way, and yielded about eight grams. The analysis showed these to be identical.

	Calculated for $Cr_2(SO_4)_3.Cr_2(OH)_6.15H_2O$.	Found. I.	II.	III.
Cr	24.06	22.41	22.40	22.69
SO_4	33.17	34.64	34.73	34.43
Water	43.77			

The agreement is far from satisfactory, but the body is evidently a basic salt.

On evaporating the liquid portions other masses were obtained. These were also analyzed :

	Calculated for $2Cr_2(SO_4)_3.Cr_2(OH)_6.20H_2O$	Found. I.	II.	III.
Cr	22.70	22.93	22.71	22.98
SO_4	42.72	42.72	43.32	43.46
Water	34.57			

This is less basic than the previous compound. As the alcohol left is decidedly acid, it must contain either free acid or an acid sulphate.

It did not seem to be necessary to prepare other chromium sulphates, as these experiments were in accord with those obtained with the alum, and lack of time made it necessary to bring the experiments to an end.

CONCLUSIONS.

On weighing the experimental evidence which has been brought to bear upon these changes, it is an easy matter to exclude some of the explanations offered. Thus the dissociation of the alum into chromium and potassium sulphates and similar theories which will not cover the cases of the nitrates, chlorides, etc., must of course be dropped. The formation of chromo-sulphuric acid, as suggested by Recoura, is not tenable in the light of the experiments performed. The theory of the change of hydration is not satisfactory, since it has been seen that a loss of one-half the water did not bring about the change of color.

The theory of Berzelius, however of the formation of basic salts of chromium which would naturally be green and uncrystallizable, offers a full and sufficient explanation of the changes, and is in accord with the observations so far as they have been verified by us. It accounts quite plausibly for the partial withholding of the sulphuric acid from precitation by barium chloride in the cold, and is strongly confirmed by the experiments with alcohol. This theory is also in accord with the facts that

the green coloration may be brought about by the addition of alkaline substances, and that it is retarded by the addition of sulphuric or nitric acid. It is also easy to apply this explanation to the cases of the nitrate, chloride, acetate, and soluble compounds of chromium. When we have opportunity we propose examining the action of alcohol upon these other compounds.

NESTING HABITS OF SOME SOUTHERN FORMS OF BIRDS IN EASTERN NORTH CAROLINA.

T. GILBERT PEARSON.

The coastal region of North Carolina, especially south of Hatteras, having its temperature moderated by warmer ocean currents affords many interesting forms of life both in the fauna and flora whose natural habitat would naturally be looked for at a much more southern point. Thus the palmetto (*Sabal palmetto*) which grows wild to a height of 30 feet on Smith's Island is also found in a more stunted form as far north as the banks of Cape Hatteras. This northward extension of the habitat of some Southern birds is somewhat in keeping with that of the flora.

While spending some time in eastern North Carolina during the past summer I observed there some species of southern birds which have hitherto been overlooked by ornithologists as occuring within the limits of this State; and my purpose in publishing the following notes is to record such of these observations as may be of interest.

Worthington's Marsh Wren.[1] (*Cistothorus palustris griseus*).

The range of this bird as given by Mr. Brewster[1] and later by Frank M. Chapman in his "Handbook of Birds of Eastern North America" is the "Coast of South Carolina and Georgia." In the marsh on Gull Island in Pamlico sound about twenty miles north of Cape Hatteras marsh wrens were found in great numbers on May 20th. The island which is approximately two hundred acres in extent is little more than a continuous salt marsh over the greater part of which the water rises at high storm tides. At the time of my visit the birds were in full song and from every side of the marsh came the notes of scores of birds. While singing the performers usually occupied positions entirely out of sight except as occasionally they would make short flights upward and burst into song as they dropped back again into the cover of the high thick grass.

It was evidently too early in the season for the birds to be breeding for, of the twelve nests found and examined, there were none that contained either eggs or young. The nests were suspended among the grass stalks at distances varying from sixteen to twenty inches above the ground or shallow waters. They were entirely roofed over and varied in form from almost round to elliptical. They were composed of the dead stems and blades of marsh grass neatly wound and woven together while the material was yet damp, thus forming a strong and very durable structure. The entrance was a small opening in

[1] This new variety was described by William Brewster in the Auk for July 1893, Vol. 10, pp. 215-219.

It differs from the species *C. palustris* mainly in having the black of the upper parts duller and less extended, brown of the sides, flanks and upper parts much paler and grayish, and the dark markings of the under parts confused and inconspicuous.

the side near the top of the nest.[1]

A specimen taken at this time was identified by Mr. C. S. Brimley, of Raleigh, N. C. as being a Worthington's Marsh Wren.

On June the 9th I heard wrens singing in the marshes near Southport which I took to be of this species but as no specimens were secured I shall not claim this as a record.

During July and the early part of August wrens were frequently heard in the salt marshes about Beaufort harbor. A visit to some of the marshes on August the 2nd resulted in the finding of a few empty nests and securing after much labor a single specimen. Wishing to be certain as to the identification of this the skin was sent to Prof. Ridgway of the Smithsomiam Institution who identified it as being a fair type of *C. p. griseus*.

This race will probably be found subsequently to be a common summer resident in suitable localities along the entire North Carolina coast.

Florida Cormorant, (*Phalacrocorax piliphus floridanus*). While Florida is the typical home of these Cormorants it has long been known that in the summer they occur along the Atlantic coast as far north as North Carolina. They have not been recorded as breeding in this State, however, as far as I have been able to learn.

Following the course suggested by numerous rumors, I penetrated the forests and swamps of Craven Co. for a distance of about eighteen miles south of Newbern and found on the 25th. of May, a colony of these birds breeding around the shores of Big Lake. The nests were located on the spreading branches of staunted cypress

[1] A typical nest shows the following external measurements, length from bottom to top 5, in. Depth, 4.25 in. Width, 3.75 in. Entrance to nest, 0.85 in. by 1.12 in. The wall of the nest varies from 0.25 to 0.50 inch.

trees standing in the water from fifty to two hundred yards from the shore. Eighteen trees were thus occupied, the number of nests each tree bore varying from one to twelve. In one tree however there were thirty-eight occupied nests.

The colony was scattered along the lake side for a distance of a mile and a half. The eggs or young contained in each nest varied from two or four in number. In color the eggs are a pale bluish white overlaid with a more or less soft calcareous coating, and measure about two and a half inches in length by one and a half in width.[1]

The young birds were covered with black down, many of them being large enough to leave their nests and climb about on the branches of the trees. In doing this they would often lose their balance on the limbs while endeavoring to escape, but instead of falling into the water the hook at the point of the long bill would invariably catch on the perch and by dint of much scratching the birds would soon regain their former position. So well could they use their bills for climbing that Mr. H. H. Brimley of Raleigh N. C. to whom some of these were sent remarked afterwards in a letter that they repeatedly climbed with apparent ease up the wire netting which composed the sides of their cage.

The food of the cormorants at this season of the year must consist largely of eels, (*Anquilla anquilla*). In

[1] The exact measurements in inches and hundredths of two sets of eggs selected at random are here given: A set of four eggs measured 2.50x1.56;2.53x1.62;2.47x1.53 and 2.50x1.56. A set of three showed somewhat smaller dimensions, 2.32x1.56;2.32x1,32 and 2.24x1.53, the average for the seven specimens being 2.42x1.55. Chapman makes no distinction in measurements between the eggs of this variety and the species from which it is derived, giving the measurements of the latter as 2.40x1.40. It is quite possible however that measurements taken from a much larger series of eggs of the Carolina bird might show quite a different result from the above.

nearly every nest signs of eels remains were seen, the young birds upon becoming excited would disgorge fragments of eels. The old birds which were taken usually had the slime of eels about their heads, necks and bills.

The trees, which contained each a number of nests, were completely covered, trunk, limbs, twigs, and nests, with a white coating caused by the fishy excrement of the birds. So white and marked an aspect did the trees present that although they were not usually over twelve or fifteen feet in height their outline could clearly be made out against the dark background of the cypress swamp as we passed in our canoe along the south side of the lake five miles away.

On Jones' mill pond near Newport, Carteret Co., cormorants were commonly reported to breed, but a search of the region failed to reveal any colony. This location is nevertheless evidently a popular roosting resort. A little before sundown on the day I visited it cormorants began to come in over the swamp and in a short time two or three hundred individuals had gathered in the cypress trees along the shores of the pond.

Anhinga, Water Turkey, (*Anhinga anhinga*). This is another bird which we may now add to the list of the *avifauna* of North Carolina. It is a bird of a tropical and subtropical America and has been known to breed as far north as South Carolina.

In damming up a stream on the Orton rice-plantation in Brunswick Co. fifteen miles below Wilmington, a pond was formed which extends back into the woods among the higher ridges for several miles. At the upper end of one of these narrow tongues of water is located a colony of some four or five hundred pairs of herons, which each year assemble to breed in the cypress trees.

While approaching this heronry on the 7th of June an anhinga was flushed from its nest in a small cypress tree about ten feet above the water. It flew rapidly

away but soon returned and was secured a few minutes later upon alighting near the nest. It proved to be a male in magnificent plumage. One other bird, also a male, was seen in the neighborhood but no other nests were noticed. The nest examined was a heavy structure of sticks and twigs lined with long gray moss (*Tillandsia usneoids*). It contained four eggs well advanced in incubation. In appearance they very much resesembled the eggs of the cormorant but are smaller, an average egg measuring 1.15x135.[1] In the neighborhood of Lake Waccamaw and the region south and east of there I occasionally heard mention of this bird from the inhabitants and do not doubt but that in suitable localities throughout the south-eastern part of North Carolina the Anhinga is a frequent summer resident.

[1] Chapman's Handbook of Birds of Eastern North America, 1897, p. 93.

THE DICHOTOMOUS GROUP OF PANICUM IN THE EASTERN UNITED STATES.

1) Contribution from my herbarium. No. iii.

W. W. ASHE.

The dichotomous section of *Panicum* presents a great difficulty to satisfactory segregation in the confusing and often nearly similar forms acquired not only by nearly related, but even quite dissimilar species in the later, branched condition which the simple primary culm generally assumes after the expansion of its panicle, and sometimes even preceding its expansion. The following descriptions are based on the character of the simple

[1] Issued Nov. 10th, 1898.

state and until one is familiar with the summer and autumnal forms assumed by different types in the group the simple state is necessary in order to make a satisfactory determination. Habit, also, is a character of great value in making determinations in this group, with specimens in either the simple or branched states; and habit should always be noted when specimens are secured. The leaves on the branches are much smaller than the primary leaves, the panicles are much smaller, and the spikelets are generally smaller and more acute. The limitations of the species are, in practically all cases, sharply defined and there are no intergradent forms.

Several of the species proposed by Lamarck, Michaux, Muhlenburg and Elliott are yet subjects of dispute or even speculation, being represented by no type specimens, while the descriptions are not sufficiently minute for accurate determination. I have been able to examine the material in the Herbarium of the Philadelphia Academy of Natural Science, which contains many specimens of Nuttall, Schweinitz, Muhlenburg, and Baldwin. The specimens of Muhlenburg and Baldwin are of particular interest; those of Muhlenburg sometimes representing his own species; while Baldwin's often indicate Elliott's, since he furnished Elliott with many specimens from Georgia. I have, besides, been able to do considerable field work in the region from which Elliott derived his material, central and southern Georgia and eastern Carolina, and have there studied the species with the view of identifying some of Elliott's species. I have found nothing so far, however, which agrees with the description of his *Panicum ovale*, *P. pauciflorum or P. strigosum*.

The group of the genus that I have designated as the dichotomous group is best developed, so far as number of species is concerned, in the south Atlantic States, probably in eastern South Carolina, or eastern Georgia, where the number of known species will probably amount

to thirty. This paper is only intended to cover the region between northern Florida and Indian Territory, and Minnesota and Maine. The dichotomous group can be characterized as follows:

Basal leaves different from those of the stem, broader, and generally shorter (except in a few species); spikelets all pediceled, not racemose on the branches, neither gibbous at base, awned, or warty. Stems erect, prostrate, or decumbent, at first simple, later (except in a few species) dichotomously or fasciculately branched, producing on the branches smaller leaves and smaller panicles.

In the following paper seventy-four species are enumerated, but the real number is probably even in excess of this.

KEY TO THE EASTERN DICHOTOMOUS SPECIES OF PANICUM.

(' = one inch. " = one twelfth of an inch. ° = one foot.)

Leaves lanceolate or ovate-lanceolate, clasping by a broadly cordate base spikelets 1¼" long or more; ligule a mere margin.

Largest leaves about 1' wide, panicle spreading.

Spikelets obovate, over 1½" long.

Nodes barbed 1. P. Porterianum.

Nodes glabrous 2. P. macrocarpon.

Spikelets elliptical, 1¼" long

Leaves ovate-lanceolate, 2'–3' long, ciliate, sheaths soft-pubescent 3. P. commelinaefolium.

Leaves lanceolate, 3' long or more, sheaths papillose-hispid 4. P. clandestinum.

Largest leaves narrower, 5"—8" wide, ligule none.

Spikelets 1¼" long.

Stems erect, sheaths clasping 5. P. commutatum.

Stems decumbent or ascending, sheaths loose 6. P. Joorii.

Spikelets 1¾" long, elliptical, plant decumbent 7. P. Manatense.

Leaves rounded at base, lanceolate or narrower, 4"—8" wide, spikelets over 1¼" long.

Branches of panicle erect, leaves glabrous, ligule none.

Sheaths sparingly papillose-hispid 8. P. xanthophysum.

Sheaths glabrous 9. P. calliphyllum.

Branches of panicle spreading, ligule pilose.

Panicle 3'—5' long, spikelets elliptical, numerous 10. P. scabriusculum.

Panicle 2'—3' long, branches and obovate spikelets few, leaves pubescent 11. P. scoparium.

Leaves narrower, 3"—5" wide, somewhat rounded at the base, spikelets 1¼"—2" long.

Ligule pilose.

Nodes barbed 12. P. malacophyllum.

Nodes not barbed, sheaths pubescent.

Branches of panicle erect or ascending, leaves spreading 13. P. malacon.

Branches of panicle ascending, leaves erect 14. P. Liebergii.

Branches of panicle spreading ... 15. P. Scribnerianum.

Ligule, nodes and sheaths glabrous.

Spikelets elliptical, 1½" long, leaves 3'—5' long 16. P. equilaterale.

Spikelets 1¼" long, leaves about 2' long.

Leaves spreading, stem nearly naked below 17. P. Ashei.

Leaves ascending, stem leafy below 18. P. Webberianum.

Leaves erect, 2"—3" wide, somewhat rounded at the base, pubescent, at least the lower ones, spikelets broadly elliptical, 1¼"—1½" long.

Stem erect, strict, leaves not crowded (western) 19. P. Wilcoxianum.

Stems much branched from the base, diffuse (southern) 20. P. Georgianum.

Leaves 3"—10" wide, lanceolate, erect or ascending, clasping by a cordate, ciliate base; lower sheaths overlapping, longer than the internodes; spikelets small, ⅞" long or less, nearly spherical, numerous.

Leaves 6"—10" wide, ascending 21. P. polyanthes.

Leaves 4"—6" wide.

Leaves ascending, spikelets ⅞" long .. 22. P. sphaerocarpon.

Leaves erect: spikelets scarcely ½" long 23. P. erectifolium.

Leaves scattered on the stem, linear-lanceolate or longer, erect, 1"—5" wide, all except the lowest narrowed to the base; branches of panicle ascending or at length spreading; spikelets 1"—1½" long, very strongly nerved, nodes not barbed.

Upper leaves not over 3" wide, middle leaves longest.

Spikelets broadly obovate.

Pubescence ascending, rigid 24. P. Addisonii.

Pubescence, if present, villous, spikelets nearly 1¼" long 25. P. consanguineum.

Glabrous or nearly so, spikelets 1" long 26. P. neuranthum

Spikelets elliptical, acute 27. P. angustifolium.

Upper leaves 3"—5" wide, much longer than the lower 28. P. Bicknellii.

Low, densely tufted; leaves linear, 1"—2" wide, erect, crowded near the base of stems, upper not reduced, narrowed to the base; branches of panicle erect or ascending; spikelets broadly elliptical or obovate, 1" or more long, nodes not barbed.

Spikelets obovate, over 1½" long, second and third scales much longer than the fourth 29. P. depauperatum.

Spikelets elliptical, second, third and fourth scales equal.

Spikelets 1"—1¼" long, basal secondary panicles developed 30. P. linearifolium.
Spikelets barely 1" long, no basal panicles developed 31. P. Werneri.

Leaves narrowed to the base, lanceolate or narrower, spikelets 1¼" —1½" long, plant nearly glabrous, lower nodes barbed 32. P. nemopanthum.

Stems simple at length fasciculately branched erect, or sometimes prostrate, stem leaves numerous, scattered, spreading or ascending, lanceolate, 1½"—8" wide, clasping by a rounded or narrowed base, the upper generally not conspicuously reduced in size, and never elongated, the basal usually shorter than those of the stem; spikelets less than 1¼" long.

Nearly or quite glabrous species without a long hairy ligule.

Nodes not barbed, spikelets ¾"—1" long.

Plant strict, erect.

Leaves spreading, narrowed to the smooth base 33. P. dichotomum.

Leaves ascending.

Base of leaves narrowed, rounded, ciliate, sheaths not spotted 34. P. boreale.
Leaves narrowed to the glabrous base, sheaths spotted 35. P. maculatum.

Plant rising from a geniculate base.

Leaves 3'—4' long, ... 36. P. Roanokense.
Leaves less than 1½' long 37. P. demissum.

Nodes barbed.

Spikelets 1" long 38. P. Mattamusketense.
Spikelets ¾" long 39. P. barbulatum.

Nodes not barbed, spikelets less than ¾" long.

Strict, not prostrate or reclining; 8'—16' high.

Leaves 1"—3" wide, with a firm, white margin 40. P. ensifolium.

Leaves 1" wide or less, densely tufted.

Branched only from the base ... 41. P. Baldwinii.
Much branched towards top of culm 42. P. Wrightianum.

Stems at first erect, at length elongated and reclining, spikelets obovate, ¾" long 43. P. sphagnicolum.

Stems prostrate, spikelets broadly elliptical ¾" long 44. P. lucidum.

Stems ascending or reclining, spikelets narrowly elliptical, 3–5" long 45. P. Cuthbertii.

Nearly or quite glabrous species with a long pilose ligule.

Spikelets ½" long or less.

Spikelets about ½" long 46. P. parvispiculatum.

Spikelets scarcely ⅓" long 47. P. leucothrix.
Spikelets ¾"—1" long, obovate.
Panicle oblong, its branches erect or ascending 48. P. Eatonii.
Panicle broadly ovate, its branches spreading.
Leaves erect, panicle 1½' long or less 49. P. Columbianum.
Leaves ascending, panicle 1'—3' long 50. P. nitidum.
Sheaths more or less pubescent and often stems and leaves.
Leaves 4"—8" wide, spikelets ¾"—1¼" long.
Strict, 2ft.—3ft tall, pubescence villous .. 51. P. Huachucae.
Stems ascending, geniculate at base.
Pubescence pilose, velvety, spikelets oval 1⅛" long 52. P. viscidum.
Pubescence villous, ascending, spikelets obovate, 1" long 53. P. ciliiferum.
Stems erect, at length decumbent, leaves appressed pubescent beneath.
Spikelets ⅞" long, leaves, ascending 54. P. tsugetorum.
Spikelets ¾" long, leaves spreading 55 P. Tennesseense.
Leaves 2"—4" wide, spreading or ascending, spikelets about 1" long.
Lower branches of panicle ascending, pubescence hirsute-papillose 56. P. Atlanticum.
Lower branches of panicle spreading.
Strict, leaves spreading, basal leaves not prominent.
Pubescence rough, ascending, spikelets nearly spherical or broadly elliptical 57. P. scoparioide.
Pubescence, villous, long, spreading spikelets elliptic 58. P. villosissimum.
Pubescence softer, ascending spikelets elliptic 59. P. pubescens.
Strict; leaves erect or ascending.
Leaves lanceolate, panicle as broad as long.
Pubescence ascending-appressed 60. P. Commonsianum.
Pubescence ascending or spreading 61. P. haemacarpon.
Leaves linear-lanceolate, panicle oblong 62. P. arenicolum.
Tufted, stems soon reclining; few-leaved, basal leaves very numerous and long 63. P. laxiflorum.
Leaves 2"—4" wide, spikelets ¾"—⅞" long.
Lower branches of panicle ascending 64. P. lanuginosum.
Lower branches of panicle wide-spreading.
Sheaths papillose-hirsute 65. P. implicatum.
Lower sheaths velvety, and nodes barbed 66. P. annulum.

Leaves less than 2" wide, erect, low species.
Panicle 1'—1½' long 67. P. meridionale.
Panicle less than 1' long 68. P. filiculme.
Stem leaves few, short, 1½' long or generally much less, distant, the densely tufted basal leaves as long as the stem leaves or nearly so, and broader; spikelets ⅛" long or less.
Basal leaves ciliate around the entire margin; otherwise glabrous.
Spikelets elliptic, 1" long 69. P. ciliatum.
Spikelets obovate, ¾" long 70. P. polycaulon.
Basal leaves soft pubescent as well as ciliate 71. P. longipedunculatum.
Margin of basal leaves not ciliate.
Stems pubescent 72. P. microphyllum.
Stems glabrous, ligule short, pubescent, ... 73. P. Brittoni.
Stems glabrous, ligule none 74. P. glabrissimum.

1) PANICUM PORTERIANUM Nash, Torr. Bul. 22:420 (1895). *P. latifolium* Walt. Fl. Car. (1788). Not. L. (1753). *P. Walteri* Poir., (1816). Not Pursh. (1814).

Stems somewhat tufted, erect, columnar, soft-villous, or nearly glabrous, at first simple, at length somewhat branched at the top. Sheaths shorter than the internodes, or the upper ones overlapping, soft pubescent, or nearly glabrous and only the nodes barbed with soft hairs, ligule a mere margin. Primary leaves ovate-lanceolate, 2'—2½' long, ¾'—1' wide, cordate at base, abruptly acuminate, glabrous or roughish above, glabrous or soft-pubescent beneath, 6—13-nerved; secondary leaves smaller. Panicle short-peduncled, 2'—4' long, ovate, the few branches ascending or spreading; spikelets rather few, obovate, acute, nearly 2" long, pubescent.

Northern Florida and Texas to Missouri and New York.

2) PANICUM MACROCARPON Le Conte, Torr. Cat. 91 (1819). Stem strict, 12'—20' high, glabrous. Sheaths glabrous; ligule a mere margin. Leaves 2'—4' long, about 1' or more broad, 7—11-nerved, glabrous, except the rough, ciliate margins. Panicle 3'—4' long, the few-

flowered branches single, ascending; spikelets nearly 2 long, broadly obovate, obtuse.

Plant bright green. Maine and Ontario, to Minnessota, Missouri and North Carolina. Generally confused with *P. Porterianum*. This species has been supposed to be confined to Vermont, New York, Pennsylvania, and New Jersey. Maine: Fernald,, 1897· Ontario: Biltmore Herbarium, No. 7066. Missouri: Stewart Weller, 1894. North Carolina: Ashe; Mitchell Co., July, 1893. Iowa: Hitchcock, 1889.

3) PANICUM COMMELINAEFOLIUM Ashe, sp. nov. Culms tufted, erect or ascending, 8′—15′ high, stout, more or less pubescent. Sheaths more than half the length of the internodes, generally softly pubescent; ligule a mere margin. Leaves crowded, longer than the internodes, spreading or ascending, ovate-lanceolate, acuminate, abruptly narrowed to the cordate base, 11–15 -nerved, 2′—3′ long, 6″—14″ wide, glabrous above, minutely pubescent beneath, the margins ciliate and serrulate. Panicle ovate, 2′—3′ long, short-peduncled, branches numerous, spreading; spikelets smooth, elliptical, 1¼″ long, the first scale one-third the length of the 7-nerved second and third. Later forms branched above, with smaller leaves, the smaller panicles partly included in the sheaths.

A species having the foliage of *P. Porterianum*, and the spikelets of *P. commutatum*. Based on material collected by Dr. J. K. Small near Stone Mt., Ga., Aug. 1—6, 1895, and distributed as *P. commutatum*.

4) PANICUM CLANDESTINUM L. Sp. pl. 58 (1753). *P. pedunculatum* Torr. Fl. U. S. 141 (1824). Culms erect from a short rootstock, often covering many square feet, 16′—3° high; stem glabrous or nearly so above, papillosehispid below. Sheaths of primary stem one-half as long as the joints or more, the lower ones papillose-hispid, the upper glabrous, the panicle long-peduncled; sheaths on the branches much crowded and overlapping, papillose-hispid, concealing the small panicles; ligule none. Largest leaves 1′ broad, 3′—5′ long, cordate at

base, taper-pointed, glabrous except the rough margins, 9—13-nerved, those on the branches much smaller. Panicle 3′—5′ long, oval, the numerous branches spreading, many-flowered ; spikelets $1\frac{1}{4}''$ long, elliptical.

Very common near the banks of streams. Related to P. scabriusculum. Torrey's P. pedunculatum represents the early form. New York: Ashe: Watkins, July, 1898. Florida: Chapman ; Apalachicola. Missouri: Eggert: St. Louis, 1897. Michigan: Sartwell; Detroit, 1892. North Carolina: Ashe ; Wilmington, 1894.

5) Panicum commutatum Schultes, Mant. 2: 24 (1824). *P. nervosum* Ell. Sk. 1:122, Not Lam. *P. nervosum* Muhl. refers to another plant. Culms somewhat clustered, erect or ascending, often somewhat purplish, smooth and glabrous. Sheaths, short, glabrous except the villous margin ; ligule a mere margin. Basal leaves lanceolate or broader, glabrous ; stem leaves spreading, lax, lanceolate, scarcely narrowed at the ciliate, cordate base, $2\frac{1}{2}'$—$3\frac{1}{2}'$ long, 6′′—3′′ wide, glabrous on both surfaces. Panicle variable, 1′—3′ long, ovate, the branches fascicled, at length spreading ; spikelets elliptical or obovate, $1\frac{1}{4}''$ long, somewhat pubescent.

Shady woods.—Very common.—Closely related to *P. Joori* and *P. Manatense*. Connecticut: Eames; Bridgeport, 1897. New York: Ashe; Ithaca, 1898. Missouri: Stewart Weller, 1894. Florida: Curtiss, 1894, No. 4636.

6) Panicum Joori Vasey, Contrib. U. S. Nat. Herb. III, 1:31 (1891). Culms tufted, ascending or prostrate, much branched from the base upwards, 8′—19′ long. Sheaths loose, often as long as the internodes, glabrous except the ciliate margins ; ligule a mere margin. Leaves very numerous, lanceolate or broader, taper-pointed, narrowed to the cordate, sparingly ciliate base, otherwise glabrous, 7—9-nerved ; later leaves much smaller. Panicle small, 1′—2′ long, nearly sessile or partly included in the upper sheath, oblong ; spikelets very long pedicelled, $1\frac{1}{4}''$ long, elliptical, acute, glabrous.

Closely related to *P. commutatum*, and *P. Manatense*. Missouri,

Tennessee and southward. Missouri: Bush, July, 1895, No. 748. Tennessee: Biltmore Herbarium; Rutherford Co. No. 2984a. Louisiana: Joor. Mississippi: Tracy, 1891.

7) PANICUM MANATENSE Nash, Torr. Bul. 24 42 (1897). Stems tufted, glabrous, ascending or decumbent, soon much branched above. Lower sheaths shorter than the internodes, loose; upper crowded; ligule a mere margin. Leaves lanceolate 2'—3½' long, 5''—7'' wide, taper-pointed, cordate at the ciliate base. Primary panicle long-peduncled, 2'—3' long, broadly ovate, spikelets acute, elliptical, about 1¾'' long, first scale one-third the length of the 7—9-nerved second and third. Whole plant dark green in color.

With the foliage and general appearance of *P. commutatum* it is distinguished from it by having larger acute spikelets, and a decumbent habit. Florida: Nash; Manatee Co., 1895, No. 2428a.

8) PANICUM XANTHOPHYSUM A. Gray, Ann. Lyc. N. Y. 3: 233(1835). Culms generally single, erect, unbranched, forming no late, fascicled branches. Sheaths with a few ascending, stiff, papillose hairs; ligule a mere margin. Leaves ascending, or erect, glabrous, 4'—6' long, 5''—7'' wide, lanceolate, narrowed to the rounded base, 5—7-nerved. Panicle long-peduncled, very narrow, the few, single branches appressed; spikelets very few, short-pedicelled, 1½'' long, obovate, first scale nearly one half as long as the 7—9-nerved second and third.

Plant light green, resembling *P. calliphyllum* in color and habit. Maine to Manitoba, south to Pennsylvania. Description based on material collected by the writer in central New York, July, 1898; and the material in the Gray Herbarum; and from Maine: Merrill, 1897.

9) PANICUM CALLIPHYLLUM Ashe, sp. nov. Stems single or few together, erect, remaining entirely simple, glabrous. Sheaths shorter than the internodes, glabrous except the ciliate margin. Leaves ascending, 3'—4' long, 4''—6'' wide, lanceolate, taper-pointed, narrowed to the rounded, ciliate base, otherwise glabrous, 7—9-nerved; basal leaves few and small. Panicle sessile or short-pe-

duncled, 2'—3' long, the few-flowered branches ascending; Spikelets 1¼'' to 1½'' long, obovate, the slender pedicels two to many times their length.

Dry soil, central New York. Plant light green, drying yellowish. Closely resembling *P. xanthophysum* to which it is related. Type material collected by the writer at Watkins, Lake Seneca, N. Y., Aug. 1898. It has also been collected by Prof. W. W. Rowlee: East Schroeppel, N. Y., June 1895.

10) PANICUM SCABRIUSCULUM Elliott, Sk. 1:121(1817). P. Nealleyi Vasey. Culms forming large tufts, erect, 2—4 feet high, at first simple, at length much branched at each joint; stem glabrous. Lower sheaths generally spotted with purple, often papillose-hirsute or villous, the upper sheaths of the primary stem glabrous and distant; secondary sheaths papillose-hirsute and overlapping; ligule pilose; nodes sometimes barbed. Leaves ascending, linear-lanceolate, about 6'' wide, 4'—7' long, the numerous branches ascending or spreading; spikelets very numerous, 1''—1¼'' long, elliptical-ovate or ovate, acute, glabrous; secondary panicles concealed within the sheaths.

The affinity of this species is with *P. clandestinum*. Ditches and sunny swamps, southeastern Virginia to Texas. Not common. Virginia: Ashe; Norfolk, 1897. North Carolina: Ashe; Moore Co. 1897. Texas: Nealley, 1892.

11) PANICUM SCOPARIUM Lam. Encl. 7: 744(1797). Culms single or a few together, erect, strict, columnar, often purplish, papillose-hirsute. Sheaths papillose-pubescent, the pubescence harsh, the upper overlapping; ligule pilose. Lower leaves distant, the upper approximate, 2'—4' long, 5''—7'' wide, firm, spreading, smooth above, beneath soft-pubescent. Panicle 2'—3' long, the few branches solitary, at length spreading, 1—4-flowered.

The affinity of this species is with P. Scribnerianum. Virginia: Small and Heller; Danville, June, 1892. North Carolina: Ashe; Chapel Hill, 1897. South Carolina: Ravenel; Aiken.

12) PANICUM MALACOPHYLLUM Nash, Torr. Bul. 24: 198, (1897). Stems somewhat tufted, erect, simple, at length much branched; sheaths rather loose, papillose-hirsute with spreading hairs; ligule a ring of short hairs; nodes barbed. Leaves narrowly lanceolate, acuminate, narrowed to the rounded base, soft-pubescent, the largest about 3' long, and 5" wide, 7–nerved. Panicle nearly sessile, the branches flexous, spreading, bearing a few short-pedicelled spikelets; spikelets about 1¾" long, obovate, acute, the first scale over one third as long as the very pubescent 9–nerved second and third.

Related to *P. Scribnerianum* from which it is separated by its soft pubescence, somewhat smaller spikelets, and more slender habit.—Middle Tennessee to Indian Territory.—Indian Territory: Bush; Sapulpa, May 1895. No. 1228.

13) PANICUM MALACON Nash, Torr. Bul. 24: 197 (1897). Stems very slender, tufted, erect, columnar, smoothish, 16'—24' high. Sheaths much shorter than the internodes, the lower smooth, the upper papillose-hispid with ascending hairs; ligule pilose. Leaves distant, spreading or ascending, rigid, glabrous or somewhat ciliate at the base, shorter than the internodes, oblong lanceolate, acuminate, narrowed or somewhat rounded at the base, 2½'—4' long, 3"—4" wide, 7–nerved. Panicle sometimes much exserted, 2'—3' long, the slender, scattered, few-flowered branches erect or ascending. Pedicels two to many times the length of the spikelets; spikelets glabrous, broadly obovate, acutish, 1½"—2" long, the first scale 1–nerved, one-third the length of the 9–nerved second and third. Later stages somewhat fasciculately branched above, the leaves a little smaller, than the primary ones and panicles barely exserted.

Dry soil Florida. Related to *P. scoparium*. Florida: Curtiss; Jacksonville, Apr. 1897. No. 5864.

14) PANICUM LIEBERGII (Vasey) Scribn. Bul. U. S.

Div. Bot. 8: 32 (1889). *P. scoparium* Lam. var. *Liebergii* Vasey, l. c. Culms single or few together, erect, 1—2 feet high, at first simple, at length much branched above, more or less pubescent with spreading hairs. Sheaths papillose-hirsute, the hairs spreading; ligule hairy. Leaves lanceolate, the largest 3'—4' long, 4''—5'' wide, rounded at the base, erect, papillose-hispid beneath, above generally glabrous. Panicle narrow, about 3' long, the flexuous branches erect or ascending. Spikelets obovate 1¾'' long, the first scale nearly one-half as long as the pubescent second and third.

Very closely related to *P. Scribnerianum*. Dry soil. According to Britton and Brown extending from Minnesota and South Dakota to Nebraska, Missouri and Ohio. Iowa: Pammell, 1896.

15) PANICUM SCRIBNERIANUM Nash, Torr. Bul. 22: 421 (1895). *P. scoparium* var. *minor* Scribn. (1894). Not *P. capillare* var. *minus* Muhl. *P. pauciflorum* A. Gray (1848). Not Ell. (1817). *P. scoparium* Watson Sixth Ed. Gr. Man. 632 (1889). Not Lam. Encl. 4:743 (1797). Culms 8'—20' high, tufted, erect, at first columnar, at length much branched above. Sheaths shorter than the internodes, from nearly glabrous, especially in the northern forms, to papillose-hispid, the pubescence ascending; nodes not barbed. Leaves spreading or ascending, lanceolate, 2'—3½' long, 3''—5'' wide, rounded at the base, smooth above, glabrous or rough beneath. Panicle 2'—3' long, broadly oval, branches rather many-flowered; spikelets obovate, 1½'' long.

Most closely related to *P. Liebergii*, and *P. scoparium*, and *P. malacophyllum*. Dry soil, North Carolina and Tennessee to Wyoming, east to Ontario and Maine. North Carolina: Ashe; Raleigh, July, 1895. Tennessee: Ruth; Knoxville; 1897. Missouri: Bush; 1894, No. 729. Wyoming: Nelson; 1894, No. 516.

16) PANICUM EQUILATERALE Scribn. Bul. 11, U. S. Div. of Agrost. 42 (1898). Stems somewhat tufted from a generally geniculate base, glabrous. Sheaths short and

glabrous; ligule a mere margin. Leaves 4'—6' long, 3''—4'' wide, oblong-lanceolate, glabrous, abruptly acuminate. Panicle 2'—3' long, oval, branches spreading, rather many-flowered; spikelets elliptical to obovate, $1\frac{1}{2}$'' long; first scale acute, fully one-half as long as the pubescent 9-nerved second and third, fourth scale acute.

Related to *P. Ashei*, but the leaves are much longer than those of that plant, while the spikelets are as long as in *P. Porterianum*. Florida: Baldwin; Fort George. Florida: Nash; Eustis, 1894, Nos. 1220 and 1674.

17) PANICUM ASHEI, Gilbert Pearson, sp. nov. *P. commutatum* Schultes var. *minor* Vasey, Contrib. from U. S. Nat. Herb., vol. 3, No. I: 32 (1892). Not *P. capillare* var. *minus* Muhl. (1817). Culm erect, strict, single or a few together from a short root-stock, very slender, glabrous, 11'—18' high. Sheaths glabrous, the lower very short; ligule none. Stem leaves rigid, spreading, lanceolate, $1\frac{1}{2}$'—3' long, 3''—4'' wide, taper-pointed, scarcely narrowed at the ciliate base, glabrous on both sides, the lowest distant, the upper approximate. Panicle 2' long or less, oval, the few branches spreading; spikelets $1\frac{1}{4}$'' long, elliptic, nearly glabrous. The autumnal form is sparingly branched above.

Common.—This species is closely related to *P. commutatum* from which it is separated by its slender, strict habit, more narrow, rigid and spreading leaves approximate at the top of the culm. Dry shady woods, New York to Georgia and Missouri. New York: Ashe; Ithaca, July 1898. North Carolina: Ashe; near Wilmington, June 1898. Missouri: Bush; Aug. 12, 1892, sub. nom. *P. dichotomum*, L.

18) PANICUM WEBBERIANUM Nash, Torr. Bul. 23: 149 (1896). Stems tufted, erect or ascending, 18'—24' high, smooth except below, where minutely puberulent. Sheaths smooth, except the ciliate margin, or sometimes puberulent, inflated, shorter than the internodes; ligule a mere ciliate margin. Leaves erect or ascending, lanceolate, narrowed to a rounded base, 2'—3' long, 3''—4'' wide, 7—11-nerved, glabrous or the base, sparingly cili-

ate, generally purplish, very numerous. Panicle 2'—4' long, one half as wide, the slender, mostly single branches spreading; spikelets obovate, apiculate, $1\frac{1}{4}$'' long, on pedicels of about the same length or longer, first scale obtuse, about one-fourth the length of the 7-nerved second and third.

Low pine land. Florida: Nash; Lake Co., May, 1894, No. 781. Related to *P. demissum* Trin. but larger in every way and erect, whereas that is ascending from a geniculate base or is prostrate.

19) PANICUM WILCOXIANUM Vasey, Bul. U. S. Div. of Bot. 8: 32 (1889). Culms somewhat tufted, erect, about 8' high, pubescent, at least below. Sheaths shorter than the internodes, papillose-pubescent with rough, appressed or ascending hairs; ligule pilose. Leaves in the simple form not crowded, ascending, nearly lanceolate, the largest about 3' long, 2'' wide, narrowed to the somewhat rounded base, pubescent. Panicle long-peduncled, 1'—$1\frac{1}{2}$' long, ovoid, compact, the branches ascending; spikelets broadly elliptical, $1\frac{1}{4}$'' long, pubescent.

Dry, sandy soil, Nebraska. Type material collected by Dr. Wilcox in 1891. Closely related to *P. Scribnerianum*.

20) PANICUM GEORGIANUM Ashe, sp. nov. Low, 4'—8' high, densely tufted, much branched below and spreading, even before flowering; stems glabrous or soft-pubescent. Sheaths generally longer than the internodes, soft-pubescent or nearly glabrous; ligule with a few soft hairs. Leaves ascending, oblong lanceolate, 1'—2' long, about 2'' wide, taper-pointed, rounded at the base, 5—7-nerved, soft-pubescent or glabrate. Panicle short-peduncled, one inch long or less, generally overtopped by the upper leaves, the few, short branches ascending; spikelets, $1\frac{1}{4}$'' long, broadly elliptical, the first scale obtuse, one-third the length of the very pubescent second and third.

Dry sandy soil, southern Georgia and Florida. Related to *P. consanguineum*. Georgia: Small; Darden Junction, McIntosh Co., June 27, 1895. Florida: Chapman; Apalachicola.

21) PANICUM POLYANTHES Schultes, Mant. 2:257 (1824). *P. multiflorum* Ell. Sk. 1:122 (1817). Not Poir (1816). *P. microcarpon* Muhl. Gram. 111 (June 1817.) Not Muhl. ex Elliott (Jan. 1817). Culms often single, erect or nearly so, 16'—30' high, glabrous. Sheaths glabrous, generally longer than the internodes and overlapping; ligule none. Leaves ascending, scattered along the entire stem, lanceolate, 3'–6' long, 6''—10'' wide, taper-pointed, glabrous except at the ciliate, cordate base; basal leaves rosulate, ovate-lanceolate, rigid. Panicle oblong or elliptical, pointed, 3'—5' long, branches fasciculate, the lower ascending. Spikelets very numerous, nearly $\frac{3}{4}$'' long, broadly elliptical or spheroid; first scale small, one-fourth the length of the pubescent 7-nerved second and third.

Moist, shady woods, not common, Florida, Texas and Indian Territory northward to Michigan and Pennsylvania. Pennsylvania: C E. Smith, Chester. Missouri: Stewart Weller, 1892. Georgia: Ashe; Albany, 1896. District of Columbia: Holm: 1896.

22) PANICUM SPHAEROCARPON Ell. Sk. 1: 125 (1817). Stems sometimes tufted, erect or ascending 12'—28' long, glabrous. Sheaths glabrous (or sometimes the lower nodes slightly barbed), the lower longer than the internodes and overlapping; ligule none. Leaves ascending, lanceolate, 2'—$2\frac{1}{2}$' long, 4''—5'' wide, long taper-pointed, ciliate at the barely rounded base, about 7-nerved. Panicle long-peduncled, oval 2'—3' long, the fascicled branches somewhat ascending; spikelets obovate or nearly spherical, $\frac{7}{8}$'' long.

Common in old fields and sunny woods, New England and Ontario to Missouri, Mexico (fide Vasey) and Florida. New York: Townsend; Niagara. 1894. Missouri: Bush; Montier, 1894, No. 763. Georgia: Small; Stone Mt. 1895. Illinois: Hill; Chicago, 1898.

23) PANICUM ERECTIFOLIUM Nash, Tor. Bul. 23: 148 (1897). *P. spaerocarpon* var. *Floridanum* Vasey, Bul. U. S. Div. of Bot. 8:33 (1889). Not *P. Floridanum*

Trin. (1834) *P. spaerocarpon* Ell. ex Chapm. Flora. First Ed. 576. Culms tufted, erect or ascending, 14'—24' high, rather stout, glabrous. Sheaths glabrous, lower generally longer than the internodes; no ligule. Leaves thick, erect, rigid, lanceolate or narrower, 2'—3' long, 4''—6'' wide, taper-pointed, rounded at the ciliate base, otherwise glabrous. Panicle 1½'—3' long, oval or oblong, branches fascicled, the lower ascending. Spikelets numerous, very small, scarcely ½'' long, spherical.

Distinguished from *P. sphaerocarpon* by having narrower, erect leaves, and smaller spikelets. Northern Florida and probably the adjacent parts of Georgia. Florida: Curtiss; Jacksonville, 1894, No. 4812.

24) PANICUM ADDISONII Nash, Torr. Bul. 25: 83 (1898). Tufted, stems erect or ascending from a geniculate base, rigid. At first simple, at length much branched, the branches erect, the lower part of the stem pubescent with long ascending hairs which become much shorter towards the top. Sheaths appressed pubescent, sometimes longer than the internodes. Leaves erect, glabrous, acuminate, lanceolate, 1'—3' long, 1½''—3'' wide; ligule pilose. Panicle, long-peduncled, ovate to oblong, the rather few branches erect or ascending; spikelets obovate, 1'' long, the first scale about one half as long as the 9—11-nerved, very pubescent second and third.

Type material from southern New Jersey. Related to *P. consanguineum*. I have found the same species in eastern North Carolina.

25) PANICUM CONSANGUINEUM Kth. Enum. Pl. 1: 106 (1833). Stems sometimes tufted, generally single, villous with soft spreading or ascending hairs, at least below, 12'—30' long, spreading or ascending from a geniculate base, at first simple, the autumnal form very much branched above, and often reclining. Sheaths shorter than the internodes, villous with soft grayish pubescence, ligule a ring of very short hairs, sometimes of longer.

Stem leaves erect, oblong-lanceolate, the largest near the middle of the stem, 2'—3½' long, 2''—4'' wide, about equalling the internodes, thickish, smooth to villous; the later leaves smooth and much smaller, densely fascicled at the upper part of the stem. Panicle long-peduncled, 2'—3' long, the few long, flexuous branches ascending, few-flowered. Spikelets 1¼'' long, broadly obovate, obtuse, abruptly contracted at the base, the second and third scales strongly 7—9-nerved, very pubescent.

Virginia: Ashe; June, 1897. North Carolina: Ashe; Chapel Hill, 1896. Florida: Curtiss. *P. oligosanthes* Schult. and *P. Rafinesquianum* Schult. are probably referable to this species.

26) PANICUM NEURANTHUM Griseb. Cat. Pl. Cub. 532 (1866). Culms somewhat clustered, at first simple, erect or ascending, 8'—20' long, at length very much branched above and reclining or spreading, glabrous or somewhat pubescent. Sheaths shorter than the internodes, the lower pubescent, the upper smooth, those of the fascicled secondary branches much crowded; ligule pubescent. Earlier leaves erect, flat, glabrous, linear-lanceolate, the largest 3'—4' long, 2''—2½'' wide, narrowed at the base, longer than the internodes; the later crowded, smaller, linear, ascending on the spreading or reclining branches, often involute, very much longer than the small, barely exserted panicles. Primary panicle oblong, 3'—4' long, glabrous, the branches at first ascending, at length spreading, the rather few large flowers borne mostly on long flexuous pedicels; spikelets about 1'' long, broadly obovate.

Dry sandy soil along the Atlantic and Gulf coasts from Virginia southward. This species is apparently very close to *P. consanguineum*. I have only been able to examine Curtiss' 3587,* which has been referred by Nash to this species, and this being in the autumnal state, is rather unsatisfactory for comparision.

27) PANICUM ANGUSTIFOLIUM Ell., Sk. 1:129(1817). *P. setaceum* Muhl. Gram. (1817). Stems generally sin-

gle, at first simple and erect, later much branched, spreading or reclining, glabrous, or below somewhat pubescent. Sheaths shorter than the internodes, the lowest generally pubescent, the upper smooth. Primary leaves erect, flat, glabrous, linear-lanceolate, the largest 3'—4' long, 2''—2½'' wide, narrowed at the base, secondary leaves much smaller and crowded at the top of the ascending or reclining branches. Primary panicle oblong, 3'—4' long, glabrous, the branches at first erect, at length spreading, the flowers on long flexuous pedicels, spikelets 1'' long, or over, elliptic, acute, abruptly contracted at the base.

Dry sandy soil from eastern Virginia southward to Texas. Maryland: Canby, 1894. Florida: Nash; Eustice, 1894. Mississippi: Kearney; Biloxi, 1896. Texas: Reverchon; Dallas, 1881, sub. nom. *P. neuranthum*.

28) PANICUM BICKNELLII Nash, Torr, Bul. 24:193 (1897). Culms tufted erect, slender, smooth above, puberulent below, a foot or more tall. Sheaths often longer than the internodes, the lower pubescent with the nodes bearded; ligule pubescent. Stem leaves linear-lanceolate, narrowed at the ciliate base, otherwise smooth, the largest 5'—8' long, 4''—5'' wide, the upper ones longest. Panicle 2'—4' long, with ascending, flexuous branches; spikelets obtuse, oval or obovate, about 1½'' long, second and third scales 9–nerved. Secondary panicles much smaller, on erect branches, and not basal as in *P. depauperatum*.

This species has the habit and appearance of *P. depauperatum*, from which it is separated by having much broader leaves and smaller spikelets. New York, Pennsylvania and New Jersey. Porter; Pennsylvania; Chambersburg, July, 1896.

29) PANICUM DEPAUPERATUM Muhl. Gram. 112 (1817). *P. strictum* Pursh Fl. (1814). Not R. Br. (1812). *P. rectum* R. & S. *P. involutum* Torr. Stems tufted, 8'–18' high erect, mostly glabrous. Upper sheaths elon-

gated, glabrous or hirsute; ligule hairy. Stem leaves erect, longest towards top of culm, 3' to 8' long, 1½"—2" wide, smooth or hirsute, sometimes involute; basal leaves similar to those of the stem but shorter. Panicle loose, 3'—5' long, branches erect or ascending, mostly single, flexuous, few-flowered, pedicels mostly very long; spikelets 1½"—2½" long, broadly elliptical or obovate, acute, the 3 nerved second and third scales much longer than the obtuse fourth.

Elliott does not seem to have known this species. Throughout the eastern United States from Maine and Florida to Texas.

Dry, sandy woods and fields. Washington, D. C.: Holm, 1895. Iowa: Bessey; Ames, 1872. Georgia: Ashe; Stone Mountain, 1896 Texas: Reverchon. New Hampshire: Eaton; Seabrook, 1898.

30) PANICUM LINEARIFOLIUM Scribn. Bul. 11, U. S. Div. of Agrost. 42 (1898). Densely tufted, 8'—14' high, stems erect, smooth. Sheaths somewhat shorter than the internodes, usually hirsute; ligule hairy. Leaves linear-lanceolate, erect, firm, 2'—6' long, 1½"—2" wide, the base barely narrowed, glabrous above, or with a few long hairs, below appressed pubescent. Primary panicle open, 2'—4' long, the mostly single branches ascending, the rather few spikelets borne on pedicels two to many times their length. Spikelets elliptical, obtuse, 1" or slightly more long, very strongly 7-nerved. Secondary panicles crowded at base of the culms.

Maine and New Jersey to Minnesota and Missouri. Distinguished from *P. depauperatum* by having more slender, obtuse spikelets; while its somewhat longer, more elliptical spikelets, its pubescence and the basal panicles separate it from *P. Werneri*. Minnnesota; Holzinger; June, 1888. Maine; Merrill; July, 1898. Illinois; Hall; 1862. Missouri: Bush, 1892.

31) PANICUM WERNERI Scribn. Brit. and Brown's Ill. Flo. 3; 501 (1898). Densely tufted, stems very slender, smooth and glabrous throughout. Sheaths smooth, ligule a mere margin. Leaves linear, erect, often overtopping the panicles, the upper leaves the longest, 3'—7'

long, 1''—2'' wide, glabrous. Panicles long-peduncled, 2'—4' long, loose, the slender flexuous, generally solitary branches ascending ; spikelets about 1'' long, obovate, the first scale about one third the length of the 7-nerved second and third. Secondary basal panicles only sparingly developed.

Very close to *P. lincarifolium*. Connecticut to Ohio in swamps. Connecticut: Eames; Fairfield, 1896. New York; Rowlee; Ithaca, 1892.

32) PANICUM NEMOPANTHUM Ashe, sp. nov. Tufted, stems erect, 14'—20' high, glabrous. Sheaths glabrous, or the lowest pubescent, the upper sometimes longer than internodes, the nodes, at least the lower ones, barbed with long hairs ; ligule none. Leaves linear lanceolate, spreading or ascending, long taper-pointed, glabrous or ciliate toward the narrowed base. Panicle 3'—4' long, broader than long, the mostly single branches wide-spreading, lax and drooping, few-flowered ; spikelets elliptic, acute, nearly 1½'' long, on long, flexuous pedicels, the obtuse first scale over one-third the length of the glabrous, 7-nerved second and third.

Type material collected by the writer April, 1895, in the Penitentiary woods, Raleigh, N. C. A very distinct species.

33) PANICUM DICHOTOMUM L. Sp. Pl. 58 (1753). *P. ramulosum* Mx. *P. nodiflorum* Lam.? Several stems together, 10' -- 24' high, erect. Sheaths, except the lowest, glabrous, lowest node occasionally barbed and its sheath pubescent. Sheaths shorter than the internodes; ligule none. Leaves spreading, lax, largest 1½'—2½' long, 3''—4'' wide, narrowed to a rounded, sparingly ciliate base, otherwise glabrous. Primary panicle 2' or more long, oval, the branches lax; spikelets 1'' long, elliptic, glabrous.

Shady woods throughout the eastern United States north of Florida and Texas. Florida: Chapman; Apalachicola. Texas: Nealley; Rock

land, 1892. New York: Rowlee; Ithaca, 1895. Maine: Fernald; 1895. This is the most common vernal species from North Carolina northward. Elliott seems to have overlooked this species. His P. dichotomum is either *P. demissum* or *P. arenicolum* or some closely related species, which, in habit, resembles *P. angustifolium*, as he compares his *P. dichotomum* with *P. angustifolium* in both habit and form.

PANICUM DICHOTOMUM ELATUM Vasey Contrib. from. U. S. Nat. Herb. vol. 3 No. 1: 30 (1892). Stems stouter, leaves longer, 2½'—3' long, panicle very much larger than in the type, 3'—4' long and fully as wide. Maryland and southward. District of Columbia: Scribner 1894. North Carolina: Ashe; Chapel Hill, 1897.

PANICUM DICHOTOMUM VIRIDE Vasey, Contrib. from U. S. Nat. Heb. Vol. 3, No. 1: 30 (1892) is a tender, slender, few flowered form, growing in very deep shady woods. It is very common to the northward, but is less common to the south. It does not branch or only sparingly during the summer, the basal nodes and sheaths are glabrous, and it is probably specific. It approaches *P. lucidum*.

P. dichotomum has been burdened with numberless varieties by later American authors, most of these varieties being well-marked species, which were so regarded by early American botanists.

34) PANICUM BOREALE Nash, Torr. Bul. 22: 421(1895). Culms generally tufted, ascending or erect, 14'—20' high, glabrous. Sheaths glabrous, except for the ciliate margin, often as long as the internodes; ligule of very short hairs. Leaves glabrous, lanceolate, or sometimes ciliate at the base, 3'—5' long ½' wide or less, taper-pointed, narrowed to the rounded base, ascending. Panicle 2'—3' long, nearly as broad, branches numerous, fascicled, very slender; spikelets 1'' long, elliptic, acutish, nearly glabrous, rather numerous, on long filiform ascending or spreading pedicels. Autumnal form unbranched.

Northern New England to Minnesota, South to Pennsylvania. Related to *P. dichotomum*. Maine: Merrill; East Cerbum. New York: Ashe; Courtland, 1898.

35) PANICUM MACULATUM Ashe, sp. nov. Culms single, erect, glabrous, at length sparingly branched. Sheaths shorter than internodes, glabrous, spotted; ligule none. Basal leaves and nodes glabrous; stem leaves ascending, largest 3'—4' long, 4''—5'' wide, lanceolate, tapering to the rounded glabrous base, margins very rough, 5—7-nerved. Panicle 2'—3' long, nearly as broad, oval, the clustered branches lax. Spikelets $\frac{7}{8}$'' long, obovate, acute.

Related to *P. dichotomum*, from which distinguished by the longer, ascending leaves and smaller spikelets. Spikelets about the size of those of *P. barbulatum*. Collected by the writer at Raleigh, N. C. May, 1895.

36) PANICUM ROANOKENSE Ashe, sp. nov. Culms somewhat tufted, 18' or more high from a geniculate base. Plant glabrous throughout. Sheaths one-half as long as the internodes or more; ligule none. Leaves glabrous, ascending, narrowly lanceolate, 2'—3' long, 2''—3'' wide, firm, 5—7-nerved. Panicle $2\frac{1}{2}$'—$3\frac{1}{2}$' long, broadly oval, the slender, fascicled branches spreading or drooping; spikelets numerous, 1'' long, elliptical-obovate, glabrous.

Type material collected by writer in dry soil, Roanoke Island, N. C. June, 1898; also collected at Rose Bay and Mackleyville, N. C., the same month.

37) PANICUM DEMISSUM Trin. Sp. Gram. 3: 319 (1836), *Panicum Nashianum* Scrib. Bul. U. S. Div. of Agrost. 7: 79 (1897). Stems tufted, 10'—18' long, very slender, wiry, rising or reclining from geniculate base, joints geniculate, purplish, glabrous or minutely rough, puberulent below, at first simple, becoming much branched above late in the season. Sheaths much shorter than the internodes, the upper ones glabrous, the lower gen-

erally puberulent; ligule none. Leaves ascending, oblong-lanceolate, 1½' long or less, about 2" wide, 1' longest and broadest near the base of the culm, the upper reduced in size, glabrous. Panicle short-peduncled or sessile, 1'—2' long, the branches short, flexuous, spreading; spikelets obovate, 1" long, contracted at the base, glabrous.

Related to *P. Webberianum*, but distinguished by being much smaller and ascending from a geniculate base. Common in the pine barrens. North Carolina; Ashe; near Newberne, 1898. Georgia; Small; near Thomasville, June, 1892. Florida; Curtiss; Jacksonville, No. 4637, 1894.

38) PANICUM MATTAMUSKETENSE Ashe, sp. nov. Erect, sometimes tufted, strict, rather stout, 2 feet to 4 feet high, often purplish, nodes strongly barbed. Lower leaves and sheaths soft-pubescent the upper glabrous; ligule pubescent, otherwise glabrous. Leaves lanceolate. 3'—5' long, 4"—7" wide, spreading. Panicle 3'—5' long, ovoid, long-peduncled, the branches numerous, clustered; spikelets ellipsoid, glabrous, pointed, 1" long, first scale one-third the length of the spikelet.

Roadsides, ditch banks and wet open woods around lake Mattamuskeet, N. C., where it grows with *P. barbulatum*. June and July. The later stages profusely branched above with shorter leaves and small few-flowered panicles. Collected by the writer, and Mr. Gilbert Pearson in June, 1898.

39) PANICUM BARBULATUM Mx. Flora, 1:49(1803). *P. discolor* Spreng, ex Muhl. Gram. 114(1818). *P. heterophyllum* Schreb? Stems erect, often tufted, 2 feet to 3 feet high, the nodes barbed, otherwise glabrous. Sheaths shorter than the internodes, glabrous; ligule pubescent. Leaves spreading or ascending, lanceolate, rounded at the base, 3'—4' long, 3"—6" wide. Panicle 3'—5' long, ovoid, peduncled, the branches fascicled, numerous; spikelets ellipsoid about ¾" or less long, pointed. The later stage very much branched above, with smaller leaves and small, few-flowered panicles.

Wet shady places, very common. Florida and Texas to (according to Britton & Brown) Ohio and Connecticut. Texas: Nealley; No. 26. Florida: Chapman; Apalachicola, Biltmore Herbarium, No. 803c. District of Columbia: Kearney, 1895. Kentucky: Miss Price; Bowling Green. This species has the general appearance of *P. dichotomum*, but is distinguished by the smaller spikelets and barbed nodes. Nearly related to *P. annulum* and *P. Mattamusketense*.

40) PANICUM ENSIFOLIUM Baldwin, Ell. Sk. 1:526 (1817). *P. albo-marginatum* Nash, Torr. Bul. 24:40 (1897). Stems tufted, branching from the base or near it, glabrous, 8'—14' high. Sheaths generally much shorter than the internodes, crowded on the branches above, glabrous, except the very short, hairy ligule. Leaves glabrous, lanceolate, mostly clustered near the base of the stem, the largest 1½'—2' long, 3''—4'' wide, the margins white and thickened, upper reduced in size. Panicles small, 1'—1½' long, long-exserted, oval, the branches ascending; spikelets numerous, ¾'' long, elliptical-obovate, the first scale about one-fourth as long as the pubescent 7-nerved second and third.

Moist or dry woods middle North Carolina to Florida. North Carolina: Ashe; Chapel Hill, June, 1896. Georgia: Baldwin. Florida: Nash; Lake county, 1894, No. 925. A specimen in the herbarium of the Philadelphia Academy of Science sent by Baldwin from Georgia, and labelled by him *P. ensifolium*, matches my material from North Carolina and Nash's from Florida. It also agrees very well with Elliott's description of this species.

41) PANICUM BALDWINII Nutt. ex Chapman, Flora, 3rd edition 586 (1896). Densely cespitose, glabrous, stems much branched near the base, low 8'—16' high, stiff and rigid. Sheaths smooth; ligule pubescent. Stem leaves rigid, erect, narrowed at base, ½'—1½' long, acuminate, glabrous. Basal leaves tufted. Panicle 1' or less long, much divided; the obovate or elliptic spikelets barely ½'' long, the second and third scales indistinctly 5-nerved.

Georgia: Baldwin, in Herb. Philadelphia Acad. of Natural Science. Florida: Curtiss; Indian river, No. 5804. Florida: Chapman; Apalachicola. Related to the next.

42) PANICUM WRIGHTIANUM Scribn., Bul. 11, U. S. Div. of Agrost., 44 (1898). Stems densely tufted, much branched above, sometimes puberulent. Sheaths very short, occasionally pubescent; ligule sometimes pubescent. Leaves lanceolate, somewhat rounded at the base, 1'—2' long, erect, glabrous, taper-pointed. Panicle oblong, ½'—1½' long, branches fascicled, short; spikelets obovate, less than ½" long, second and third scales faintly 5-nerved.

Florida and westward along the South Atlantic and Gulf coasts. Florida: Nash; Lake county, 1894, No. 1238. Florida: Curtiss; Jacksonville, 1894, No. 5588. North Carolina: Ashe; near Newberne, 1898.

43) PANICUM SPHAGNICOLUM Nash, Torr. Bul. 22: 422 (1895), Cespitose, stems at first erect, soon reclining and much elongated, 12'—30' long, very slender, glabrous. Sheaths much shorter than the internodes, glabrous, no ligule. Leaves erect, ½'—1½' long, 2"—3' wide, narrowly lanceolate, narrowed to the somewhat rounded base, glabrous, 5-nerved. Panicles 1'—1½' long, branches erect, or ascending; spikelets ¾" long, broadly obovate, glabrous, the second and third scales 7-nerved.

Delaware to Florida and Tennessee. At first unbranched, eventually with slender, reclining branches and small, sessile panicles. Color light green. Delaware: Canby; Ogleton, June, 1896. District of Columbia: Kearney; June, 1897. North Carolina: Small; Duns' Mt., August, 1894. North Carolina; Biltmore Herbarium, Biltmore, August, 1898 No. 5066b. Florida; Nash, No. 2500.

44) PANICUM LUCIDUM Ashe, sp. nov. Cespitose, culms reclining or prostrate, weak, glabrous. Sheaths glabrous, except the ciliate margin, very short; ligule none. Leaves spreading, 1' long or generally less, narrowly lanceolate, very acute, narrowed to the base, glabrous, rather distant. Panicle peduncled, 1½' long or less, equally as wide, the branches single or several together,

wide-spreading; spikelets about $\frac{7}{8}$'' long, elliptic or narrowly obovate, acute, glabrous.

Collected in June 1898 by the writer in deep, shady swamps bordering lake Mattamuskeet, N. C. Probably found in other swamps along the coast of the southern states. Very different from *P. sphagnicolum*.

45 PANICUM CUTHBERTII Ashe, sp. nov. Culms very slender, erect or spreading, densely tufted, glabrous, 8'—24' long, the autumnal state unbranched or slightly so. Sheaths very short, glabrous; no ligule. Stem leaves distant, narrowly lanceolate, taper-pointed, 3 to 5 nerved, narrowed at the base, thin, glabrous, $\frac{1}{2}$'—$1\frac{1}{2}$' long, 1''—2'' wide, spreading or ascending; basal leaves densely tufted. Panicle broadly oval about 1' long, the slender branches spreading; spikelets narrowly elliptical, acute, $\frac{1}{2}$'' long, the first scale one-fourth the length of the 7-nerved finely pubescent second and third.

Wet sandy woods, North Carolina and South Carolina. South Carolina: Cuthbert; St. Helena island. North Carolina: Ashe; Chapel Hill, June, 1898. It is separated from *P. ensifolium* by the strict habit and large basal leaves of the latter; while *P. sphagnicolum* has the branches of its panicle ascending and larger obovate spikelets; and *P. lucidum* has much larger and broader spikelets, and a decumbent habit.

46) PANICUM PARVISPICULATUM Nash, Torr. Bul. 24:347 (1897.) *P. microcarpon* (?) Muhl. ex Ell. Sk. 1:127 (1817). Stems tufted, erect, 8'—30' high, glabrous, or with some appressed pubescence on the lower part and sometimes with the nodes barbed. Sheaths very short, generally glabrous, the lower sometimes pubescent; ligule short, pilose. Leaves distant, ascending, much shorter than the internodes, lanceolate, narrowed at the base, 2'—3' long, 3''—4'' wide, generally glabrous. Basal leaves oblong lanceolate, 2'—4' long, about 4'' wide, stiff and erect. Panicle $1\frac{1}{2}$'—3' long, oval or oblong, the numerous ascending branches thickly fascicled; spikelets very numerous, small, scarcely $\frac{1}{2}$'' long, broadly oval.

This species is intermediate between *P. leucothrix* Nash. and *P. niti-*

dum Lam., and is the *P. nitidum* of Dr. Chapman's Southern Flora. It is also probably the *P. microcarpon* of Elliott. It occurs along the coast as far north as eastern Virginia. As it is variable in the amount of pubescence, some specimens being quite glabrous, and others having the stems and sheaths pubescent, and nodes barbed, it is possible that Elliott may have based his *P. microcarpon* on specimens of the pubescent form. Virginia: Curtiss; Bedford Co., 1873, sub nom. *P. nodiflorum* Lam. North Carolina: Ashe; Wilmington, 1895. Florida: Chapman; Apalachicola. Curtiss, Jacksonville, No. 4033.

47) PANICUM LEUCOTHRIX Nash, Torr. Bul. 24:41 (1817). Stems somewhat tufted, slender, 12'—30' tall, glabrous, or pubescent below. Sheaths shorter than the internodes, glabrous or the lower pubescent; ligule pilose. Leaves lanceolate, $1\frac{1}{2}$' long or less, 1"--2" wide, narrowed to the base, spreading or ascending. Panicle oblong, $\frac{3}{4}$'—$1\frac{1}{2}$' long, the numerous short fascicled branches ascending; spikelets very numerous, less than $\frac{1}{2}$" long, spheroid, whitish or purple.

Central Florida to North Carolina near the coast. Florida: Curtiss; Jacksonville, 5912. North Carolina: Ashe; Manteo, June, 1898. Reated to *P. parvispiculatum*. This is Elliott's *P. nitidum*.

48) PANICUM EATONII Nash, Torr. Bul. 25: 84 (1898). Erect, 1'--3' tall, glabrous. Sheaths smooth: ligule pilose. Leaves lanceolate, taper-pointed, ascending, becoming much smaller towards top of culm, the largest 3'--4' long, and 4"--5" wide: panicle long-peduncled, oblong, 3'--5' long, the numerous short branches ascending; spikelets oval, about $\frac{3}{4}$" long, first scale about one-third as long as the pubescent, 7-nerved second and third.

"Wet places along the coast, Maine to New York." Description based on material sent me by Mr. A. A. Eaton of Seabrook, N. H.

49) PANICUM COLUBIANUM Scribn. Bul. U. S. Div. of Agrost. 7: 78 (1897). Stems somewhat tufted, 8'–20' high, strict, glabrous or the lower pubescent: ligule pilose. Leaves distant, ascending, lanceolate, taper-pointed, the upper reduced in size, largest 2'--3' long,

3"—4" wide. Panicle long-peduncled, mostly smooth, 1'—2' long, at first contracted, later pyramidal, branches numerous, fascicled; spikelets broadly ovate, ¾" long purplish, first scale minute, second and third 7-nerved, pubescent. Later stages fasciculate branched, the small branches and leaves ascending.

Too close to *P. nitidum*, from which it is distinguished only by its smaller size, and smaller panicle. New Jersey: Commons; 1897. District of Columbia: Kearney; June, 1897.

50) PANICUM NITIDUM Lam. Encl. 4; 748 (1797). Stems often tufted, erect, strict, 10' to 3½ feet high, nearly glabrous; later stages much branched from the sheaths. Sheaths shorter than the internodes, glabrous or with soft ascending hairs, or, to the southward, the lower sheaths papillose-hirsute; ligule pilose. Leaves firm, ascending, 7—9-nerved, oblong-lanceolate, 2'—4' long, 3"—4" wide, glabrous, or appressed pubescent beneath, shorter than the internodes; upper much reduced. Panicle 2'—3' long, broadly oval, at least the lower branches ascending, spikelets numerous, on very slender pedicels, about ¾" long, broadly ovate.

New England to North Carolina, and Wisconsin. Its distribution farther westward undetermined.

District of Columbia: Kearney; 1897. North Carolina: Ashe; 1898. Wisconsin: Pammel; Prairie du Chien, 1891.

This is a very confusing and variable species. I have studied it in the field for three seasons and have carefully noted its variability. To the northeast, where it is common at least as far as New Jersey, it is generally glabrous or nearly so; to the southward it is often pubescent, with the sheaths papillose-hirsute, though the glabrous form occurs occasionally along with it. It is variable in size and in the shape and size of its spikelets, even on the same individual. The long pilose ligule, however, is constant. To the extreme southeast *P. leucothrix* occurs, which is closely allied to *P. nitidum*, and is the *P. nitidum* of Elliott. It is also very variable in its pubescence and in the size and shape of its spikelets. In the extreme west *P. nitidum* is represented by *P. thermile* Boland, a rather low, nearly glabrous species; while closely allied to it is a very villous form with larger, narrower spikelets, which seems to be specific. Its description follows:

51) PANICUM HUACHUCAE Ashe, sp. nov. Stems somewhat clustered, erect, slender, villous, 2 feet to 3 feet high. Sheaths shorter than the internodes, villous to papilose-hirsute; ligule long-pilose. Leaves erect or ascending, 3'--4' long, 3"--4" wide, generally villous, oblong-lanceolate. Panicle 3'—5' long, oval, pubescent; spikelets nearly 1" long, oval, or elliptical, pubescent.

Based on: Lemmon: *P. dichotomum* var. *nitidum*, subvar. *barbulatum*; Huachuca Mountains, Arizona, 1882. North Carolina: Ashe; Chapel Hill, June, 1898. Iowa: Bessey; Ames, 1875. Delaware: Commons; sub nom., *P. lanuginosum*. Missouri: Glatfeller; St. Louis, 1897.

52) PANICUM VISCIDUM Ell. Sk. 1: 124 (1817). *P. scoparium* Mx. Flora 1: 49(1803). Not Lam. (1797). Tufted, large and stout, 2 feet to 3 feet high, ascending, from a generally geniculate base; stem pilose, especially below. Sheaths shorter than the internodes, pilose on the lower part, the upper generally viscid, barbed at the nodes, with a naked viscid ring below the node; ligule of very short pubescence. Leaves 3'—5' long, 4"—7" wide, lanceolate or narrower, narrowed to the base, glabrous above, generally pilose beneath. Panicle short-peduncled, 2'—4' long, broadly oval, the numerous, fascicled branches ascending; spikelets broadly obovate or nearly spherical, $1\frac{1}{8}$" long, apiculate; axis of panicle often viscid. Later state much branched.

New Jersey to Florida and Texas. Frequent in wet or moist sandy places. Florida: Chapman, Apalachicola. Delaware: Canby, 1894. Texas: Reverchon. North Carolina: Ashe, 1897.

53) PANICUM CILIIFERUM Nash, Torr. Bul. 24: 195 (1897). Culms tufted, erect or ascending from a geniculate base, the joints geniculate. 18' -- 24' high. more or less villous below with appressed or ascending hairs, above smooth. Sheaths much shorter than the internodes, villous with soft, appressed pubescence; pubescence of ligule very short or sometimes long and villous.

Stem leaves erect or ascending, long-acuminate, broadest near the somewhat rounded base, the lowest lanceolate, 2'—4' long, 4"—5" wide, 9—13-nerved, the upper much reduced. Panicle pyramidal, 2'—4' long, the fascicled branches very long and slender, spreading or the lowest reflexed, spikelets purple, obovate, abruptly contracted at the base, 1" long, the first scale one-third the length of the smooth, 9-nerved second and third.

Shady pine lands, Eastern North Carolina to Florida. North Carolina: Ashe, Manteo, 1898. Florida: Curtiss; Jacksonville, 1897, No. 5866. Related to *P. arenicolum* but larger in every way, more pubescent, and with longer leaves.

54) PANICUM TSUGETORUM Nash, Torr. Bul. 25: 86 (1898). Stems tufted, 18' or less high, at first erect, and simple, at length much branched above and prostrate, pubescent with short ascending hairs, or with longer ones towards the base. Sheaths shorter than the internodes, pubescent with ascending hairs; ligule short, pubescent. Leaves lanceolate, the largest 2'—3' long, 3"—4" wide, later ones smaller, glabrous above, beneath appressed pubescent. Panicle broadly oval, about 2' long, the branches ascending; spikelets broadly obovate, about $\frac{7}{8}$" long, pubescent.

Hemlock woods; Connecticut, and New York.

55) PANICUM TENNESSEENSE Ashe, sp. nov. Tufted, low, 5'—12' high, erect or ascending from a geniculate base, very slender, at first simple, soon densely branched above with short branches, glabrous or nearly so. Sheaths often nearly as long as the internodes, at least the lower ones covered with a short, soft pubescence; ligule short-pilose. Leaves spreading, thin, 3—5-nerved, the margins very rough, smooth above, beneath appressed pubescent and roughish, the largest $2\frac{1}{2}$'—3' long, 3"—4" wide, widest in the middle, abruptly pointed, narrowed to the rounded base; secondary leaves thickly

crowded above, about 1' long, spreading, much longer than the very numerous, short, secondary panicles. Primary panicles short-peduncled, 1'—2' in length, oval, the spreading branches mostly single, rather few flowered, the slender peduncles two to many times the length of the obovate, pubescent, ¾" long spikelets.

Related to *P. Joorii*, which it somewhat resembles. Based on No. 7087 Biltmore Herbarium: Cedar glades, LaVergne Co., Tennessee.

56) PANICUM ATLANTICUM Nash, Torr. Bul. 24:346 (1897). Culms tufted, erect or ascending from a usually geniculate base, 10'—20' high. Stem more or less pilose with spreading or ascending hairs, the nodes long-barbed above the naked ring. Sheaths pilose to villous, generally papillate, the lowest nearly as long as the internodes, the upper much shorter; ligule pilose, hairs 2"—3" long. Stem leaves ascending, above smoothish, below generally villous, the margins often ciliate with long hairs, 2'—3' long, 2"—3" wide, linear-lanceolate; narrowed at the somewhat rounded base, taper-pointed, middle leaves the longest; basal leaves much shorter; the later leaves on the secondary branches, ascending, one-half the length of the primary, smooth. Panicle 2'—3' long, nearly as wide, long-peduncled, the branches somewhat ascending, spikelets rather numerous, obovate, acute, quite 1" long, the first scale full one-third as long as the minutely pubescent 9-nerved second and third; later panicles not expanding, one-half the length of the surrounding leaves.

New York to North Carolina, and probably farther southward, generally near the coast. Delaware: Commons; 1872. North Carolina: Ashe; Cape Hatteras, 1898.

57) PANICUM SCOPARIOIDE Ashe. sp. nov. Stems single or a few together, erect, columnar, 16'—20' high, appressed pubescent. Sheaths papillose-pubescent, with ascending or appressed hairs, the lower much shorter than the internodes, the upper longer; ligule pilose.

Leaves linear-lanceolate, spreading and ascending, 2'—3' long, about 3" wide, rounded at the base, generally 9-nerved, beneath appressed pubescent, above glabrous, lower leaves distant, the upper approximate. Panicle 1½'—2' long, broadly oval, the branches fascicled, spreading, spikelets rather numerous, broadly obovate, somewhat over 1" long, apiculate, the acute first scale scarcely one-third the length of the nearly smooth 7-nerved second and third.

A species with the habit of *P. scoparium*, and spikelets which are nearly the size and shape of those of *P. viscidum*. Based on No. 283, ex Herb. A. Commons. Dry soil, Centreville, Del. June, 1873. Distributed sub nom. *P. Scribnerianum* Nash.

58) PANICUM VILLOSSISSIMUM Nash, Torr. Bul. 23: 149 (1896). Stems erect or ascending, tufted, slender, 16'—24' high, villous with long, ascending hairs, barbed above the glabrous nodes, joints geniculate. Sheaths much shorter than the internodes, villous; ligule pilose. Stem leaves linear-lanceolate 2½'—4' long, 3"—4" wide, rounded at the base, ascending, longest about the middle of the culm, the upper scarcely reduced, more or less villous with spreading hairs; basal leaves much shorter and not conspicuous. Panicle 2½'—3½' long, equally as broad, the numerous slender branches fascicled; spikelets obovate, about 1" long on slender pedicels.

Collected by Dr. J. K. Small in the Ocmulgee river swamp in May, 1895. Related to *P. pubescens* and *P. haemacarpon*.

59) PANICUM PUBESCENS Lam. Encl. 4:748 (1797). Culms tufted' 10'—20' high, slender, erect, joints geniculate, stem to base of panicle villous with long, white, spreading hairs, a ring of longer hairs above the joint, below which is a naked ring. Sheaths about one half the length of the internodes, villous with long white hairs, minutely papillate; ligule pilose. Stem leaves ascending, linear-lanceolate, gradually narrowed at the base, taper-

pointed, villous to sparingly hirsute, 7--9-nerved, the longest about 3' long and 3'' wide; upper leaves much reduced in size; basal leaves hirsute, shorter and broader. Panicle about 2 inches long, nearly as broad, the branches single or in pairs, spreading or ascending; spikelets somewhat obovate, obtuse, scarcely 1'' long, first scale one third the length of the pubescent, 7-nerved second and third; peduncled 2 to 3 times the length of panicle. The late form densely fasciculately branched and spreading.

Maine to Iowa, Georgia and Missouri. Very close to *P. implicatum*. Maine: Merrill, 1895. Georgia: Ashe; Atlanta, 1896. Iowa: Cratty; Armstrong, 1889, No. 1067. Missouri: von Schrenk; St. Louis, 1897.

60) PANICUM COMMONSIANUM Ashe, sp. nov. Stems clustered, erect, strict, 8'—16' high, below appressed pubescent, above glabrous or puberulent. Sheaths shorter than the leaves or the lower overlapping, the lower appressed pubescent with ascending hairs, the nodes densely barbed with short ascending hairs. Leaves glabrous, or sparingly ciliate near the base erect or ascending, narrowly lanceolate, gradually narrowed to the apex from near the base; 1½'—2' long, ligule pilose. Panicle 1½' —3' long, as broad as long, the branches fascicled, spreading, long-peduncled, glabrous or the axis puberulent; spikelets 1'' long, obovate, or broadly elliptical, pubescent. Roots very long and fibrous.

Based on No. 341, Commons. Collected in drifting sands along the coast, Cape May, N. J. June, 1898. Related to *P. haemacarpon*.

61) PANICUM HAEMACARPON Ashe, sp. nov. Tufted, stems erect or ascending from a geniculate base, 12'—18' high, below villous with long spreading or ascending hairs, above sometimes smoothish. Sheaths shorter than the internodes, papillate, villose with long soft, spreading hairs; the nodes bearded with spreading or reflexed hairs.

Leaves erect or ascending, 1'—2' long, 2''—3'' wide, lanceolate, the middle ones longest, the upper much reduced, the lower pilose beneath, the upper pubescent with long scattered hairs on the upper surface, appressed pubescent, often papillate, beneath. Panicles 1½'—2' long, broader than long, the branches wide-spreading somewhat fascicled, rather few-flowered; spikelets 1'' long, broadly obovate, apiculate, the first scale one-third the length of the pubescent second and third. Spikelets generally red, or purplish.

Closely related to *P. villossissimum* from which separated by its generally ascending habit, erect leaves, the upper reduced, and shorter usually ascending pubescence. District of Columbia: Kearney; 1897. Ashe: North Carolina; Chapel Hill, 1898. Iowa: Carver; Jewell Junction, 1895, No 258.

62) PANICUM ARENICOLUM Ashe, sp. nov. Erect from a usually geniculate base, 10' to 24' high, pubescent, at least below, with soft ascending hairs. Sheaths shorter than the joints, pubescent with short ascending hairs Stem leaves erect or ascending, longest near the base of the stem, much reduced in size upward, the largest 2'—3' long, 2" wide, long taper-pointed, glabrous above, beneath more or less papillose-pubescent. Panicle long excerted, 2'—3' long pyramidal, the flexuous fascicled branches spreading, at length reflexed. Spikelets somewhat less than 1" long, obovate, obtuse.

Intermediate in size, habit, and general characters between *P. ciliiferum and P. demissum*, smaller than the former and larger than the latter. Type material collected by the writer at Chapel Hill, N. C. June 1898, and later at several localities in the eastern portion of the same state.

63) PANICUM LAXIFLORUM Lam. Encycl. 4: 748 (1797). *P. Muhlenbergii* Nutt. in Herb. *P. acuminatum* Swarz. ex Muhl. Gram. Stems densely tufted, ascending or spreading or later reclining, 15'—20' long, smooth or somewhat pubescent. Sheaths very short,

one-third the length of the leaves, papillose-hirsute: ligule a mere margin. Stem leaves few, mostly near the base of the culms, ascending or spreading, narrowly lanceolate, very taper-pointed, narrowed at the base or somewhat rounded, 7 to 9-nerved, the largest 3'—4' long, 4''—5'' wide, the upper leaves, scarcely reduced in size, glabrous or hirsute with long white hairs, often with ciliate margins; basal leaves shorter but similar to those of the stem, ciliate-margined, often hirsute, very abundant, soft and lax. Panicle 3' to 4' long, obovate, the branches slender, lax; spikelets obovate, about 1'' long, the acutish first scale one-fourth the length of the very pubescent, 9-nerved second and third.

Late panicles included in very short sheaths which are not longer than the basal leaves. Primary culms do not become fasciculately branched. Color light green. Damp shady hillsides, Maryland and Kentucky to Alabama and Florida. The basal leaves form large tufts which remain green throughout the winter. It is one of the earliest spring species. April-July. West Virginia; Small, 1892. Florida; Curtiss, Juniper, 1895, No. 5537. Tennessee; Ruth, 1897. *Panicum caricifolium* Scribn. in herb. as distributed by Kearney (Washington, D. C., May, 1897) differs from this only in its somewhat smaller—quite ¾'' long spikelets.

64) PANICUM LANUGINOSUM Elliott. Sk. 1:123 (1817). Stems ascending from a geniculate base, rather stout, 12'—24' long, villous below, pubescent above. Sheaths shorter than the leaves, the lower, at least, densely pilose with soft pubescence, the upper often glabrous, barbed above the naked joint; ligule a ring of long hairs. Stem leaves lanceolate, rounded at the base, spreading or ascending, the largest near the base of the stem, 2½'—3' long, 3''—4'' wide, 9—11-nerved, generally soft-pubescent beneath, glabrous above, or the lowest pilose on both sides, finely ciliate on the margins, particularly the upper ones toward the base; upper leaves much reduced in size. Panicle 2'—3' long nearly as wide, the numerous, fascicled, smooth branches ascending; spikelets small for size of

plant, about $\frac{3}{4}$'' long, obovate, very pubescent, first scale about one-third as long as the 7-nerved second and third. Peduncle twice the length of panicle.

Dry sandy fields, New Jersey to Georgia near the coast. Related to *P. viscidum*. Description based on plants growing at Chapel Hill, N. C. Delaware: Commons; Mt. Cuba, 1871. Washington, D. C.: Kearney; 1897 Ashe; North Carolina: Chapel Hill, 1898.

65) PANICUM IMPLICATUM Scribn. Bul. 11, U. S. Div. of Agrost. 43 (1898). Culms erect, tufted, 12'—20' high, very slender, somewhat geniculate at the nodes. Stem, to base of panicle, more or less pubescent with short white hairs, barbed above the naked ring at the joints. Sheaths about one-half the length of the internodes, more or less hirsute, at least below; ligule a ring of hairs 2'' long. Stem leaves ascending, linear-lanceolate, gradually narrowed to the base, 2'—3' long, about 3'' wide. 7—9-nerved, more or less pubescent; basal leaves much shorter, nearly glabrous. Panicle 1' or more long, about as wide, the numerous slender branches spreading; spikelets obovate, apiculate, $\frac{1}{2}$''—$\frac{3}{4}$'' long, first scale minute, one-fourth as long as the nearly glabrous, 7-nerved second and third. Color of plant green, often purplish. Late stages much branched above.

Northeastern States. Specimens examined: New Jersey; Commons, 1897. New York: Wiegand, Ithaca, 1893. New York: Ashe; Watkins, June, 1898. New York: Ashe; Courtland, Aug. 1898. Maine; Merrill, 1897. Its smaller leaves, more branched panicle, and smaller spikelets separate this plant from *P. pubescens* to which it is most closely related.

66) PANICUM ANNULUM Ashe, sp. nov. Stems erect, generally single, 18'—30' high, below pilose, above generally glabrous, purple. Sheaths shorter than the internodes, at least the lower soft-pilose, nodes barbed; ligule very short, pubescent. Leaves lanceolate, 3'—4' long, 4''—6'' wide, narrowed to the rounded base, the lower pilose on the lower surface, the upper generally glab-

rous, purplish, spreading. Panicle 2'—3' long, oval, the fascicled branches spreading or reflexed; spikelets about $\frac{3}{4}$'' long, narrowly obovate, pubescent; the axis of the panicle generally viscid. The later stage much branched.

Dry rocky woods. Maryland to North Carolina and Georgia. Near Washington, D. C. Ward; 1892. North Carolina: Ashe; Chapel Hill, 1898. Georgia: Ashe; Stone Mt., 1896. Related to *P. barbulatum*, but has a smaller panicle, and is pubescent.

67) PANICUM MERIDIONALE Ashe, sp. nov. Stems 4'—8' high, densely tufted, erect or ascending, villous with ascending hairs, purplish, very leafy. Sheaths striate, villous with ascending hairs, generally shorter than the internodes; ligule pilose. Leaves numerous, erect or ascending, 1'—$1\frac{1}{2}$' long, about 2' wide, lanceolate, rounded at the base, beneath pubescent with short ascending hairs, above with a few scattered long hairs, or towards the base of the leaf villous. Panicle glabrous 1'—2' long, the branches single or a few together, ascending; spikelets elliptical or obovate, nearly $\frac{3}{4}$'' long, the first scale about one third the length of the glabrous second and third.

I have collected this species at two localities in North Carolina, Chapel Hill in June, 1898; and Jonas Ridge, Burke Co., June, 1893. As these two stations are far apart the plant probably occurs in other States to the north and south of North Carolina. Dry rocky woods. Very different from either *P. filiculme*, *P. implicatum* or *P. pubescens*.

68) PANICUM FILICULME Ashe, sp. nov. Stems tufted, or single, at first simple, later fasciculately branched above, erect, very slender, 6'—10' high, more or less villous with ascending hairs. Sheaths villous with ascending hairs, shorter than the internodes; ligule of very short pubescence or of long hair. Leaves narrowly lanceolate, $1\frac{1}{2}$' long or less, 1''—2'' wide, rounded at the base, the lower surface papillose, appressed pubescent, the upper nearly glabrous, hirsute, or merely the mar-

gins fringed with long erect hairs, the upper leaves reduced in size; secondary leaves smaller, longer than the panicles. Panicle long-peduncled, small, about ½' long, the rather short branches, erect or ascending; spikelets broadly obovate, obtuse, about ½'' long.

Dry soil, middle North Carolina to Georgia in the Piedmont plateau region. Related to *P. implicatum* and *P. pubescens*. North Carolina: Ashe; Chapel Hill, 1898. Georgia: Small; Stone Mt., Aug. 1895.

69) PANICUM CILIATUM. Ell. Sk. 1:426 (1817). *P. ciliatifolium* Kth. Stems erect, 8'—16' high, smooth, slender. Sheaths smooth; ligule not hairy. Stem leaves, one to three, lanceolate, 1'—2' long, 2''--3'' wide, smooth except for the ciliate margins; basal leaves very numerous, broader and longer than the stem leaves, the entire margin ciliate with long hairs, otherwise glabrous. Panicle rather small, 1'—2' long, nearly as wide, the fascicled branches ascending or spreading; peduncles 4 to 5 times the length of the panicle, smooth, spikelets on very slender pedicels, 3 or more times their length, nearly 2'' long, obovate, acute, the first scale nearly one-half as long as the smooth 7-nerved second and third.

Color pale green. Rather uncommon. Ditch banks and sandy swamps, eastern North Carolina to Florida. A beautiful species. North Carolina: Ashe; near Wilmington. 1897. Florida: Biltmore Herbarium; Apalachicola, No. 6022 a.

70) PANICUM POLYCAULON Nash. Torr. Bul. 24:200, (1897.) Stems densely tufted, 6'—10' tall, simple, nearly naked, at length somewhat branched, sheaths loose, glabrous, the margins ciliate, upper longest; ligule pubescent. Stem leaves ascending, lanceolate, the longest about 3' long, 4'' wide, ciliate on the margins 7—9-nerved; basal leaves numerous, ciliate. Panicle about 1' long, its axis somewhat pilose; spikelets about ¾'' long, obovate, first scale about ½' long, as the 7-nerved, glabrous second and third.

"The narrower leaves more slender culms, and smaller and glabrous

spikelets well distinguish this from *P. ciliatum* Ell., to which it is most nearly allied." Florida and Cuba.

71) PANICUM LONGIPEDUNCULATUM Scribn. Stems erect, somewhat clustered, 6'—10' high; sheaths villous with spreading hairs, or nearly glabrous inflated; ligule hairy. Stem leaves few, distant, ascending, 2"—3" wide, lanceolate, narrowed to the somewhat rounded base, soft pubescent on both sides, the margin ciliate; basal leaves rather numerous, as long and as wide as those of the stem, pubescent on both sides, ciliate on the margins. Panicle about 2' long, oval, the axis pubescent, branches fascicled, spreading, slender; spikelets obovate, barely $\frac{1}{2}$" long, obtuse, the first scale one-half the length of the smooth 7-nerved second and third, pedicels 3 to 4 times the length of the spikelets.

Color pale green. Ditch banks and wet sandy places, eastern North Carolina to Florida. North Carolina: Ashe; Roanoke Island, June, 1898. Florida: Curtiss; Jacksonville. The basal leaves of this species, like those of *P. ciliatum*, are much more prominent than the stem leaves, and the stems, having rather few leaves, appear rather naked. The autumnal stage is not fasciculately branched.

72) PANICUM MICROPHYLLUM Ashe, sp. nov. Somewhat tufted, 8'—20' high, slender, ascending or reclining, glabrous or pubescent with long white ascending hairs. Sheaths glabrous or pubescent, very much shorter than the internodes; ligule pilose. Stem leaves distant, ascending, linear-lanceolate, 1' long or less, 1"—2" wide, generally more or less villous. Basal leaves crowded, 1' or more long, 3"—4" wide. Late forms somewhat fasciculately branched above. Panicle long-peduncled, about 1' long, the slender branches ascending; spikelets, $\frac{1}{2}$"—$\frac{3}{4}$" long very broadly obovate, the minute first scale acute, one-fourth the length of the 7-nerved second and third.

Related to *P. angustifolium*. Collected by the writer June, 1898, at Chapel Hill, N. C., in moist sunny woods.

73) PANICUM BRITTONI Nash. Torr. Bul. 24:194 (1897). Stems tufted, glabrous, very slender, erect, stiff. Sheaths, glabrous, very short; ligule pubescent. Leaves longer than the sheaths, few in number, the middle leaves longest, $1\frac{1}{4}$ long or less, less than $1\frac{1}{2}$" wide. Panicle 1' long or less, branches rather few, spreading; spikelets obovate, obtuse, $\frac{3}{4}$" long, pubescent.

Moist sand, in pine woods. Southern New Jersey.

74) PANICUM GLABRISSIMUM Ashe, sp. nov. Culms very slender, 12"—20" high, tufted, erect smooth and glabrous throughout. Sheaths much shorter than the internodes, glabrous; no ligule. Stem leaves very short, distant, less than 1' long, less than $1\frac{1}{2}$" wide, narrowed to the base, erect or ascending, glabrous or sometimes with the narrowed base sparingly ciliate. Basal leaves $1\frac{1}{2}$' long or less, 2"—3" wide, ascending, glabrous. Panicle, peduncled, about 1' long, quite as wide, branches wide-spreading; spikelets, broadly oval or spheroid, about $\frac{3}{5}$" long, glabrous or nearly so, purple.

The type material was collected by me June 1898, at Manteo, Dare Co., N. C.

NATURAL SCIENCE OF THE ANCIENTS AS INTERPRETED BY LUCRETIUS.

F. P. VENABLE.

There is no work, coming from an ancient author, which gives so full a picture of the beliefs and theories of ancient times as to the physical side of nature as Lucretius'

poem *De Rerum Natura*. It is by reading this that one may get the best insight into the ancient habit of thought concerning natural phenomena and the poem can be recommended to all who are fond of tracing over again ancient by-paths and half-lost tracks.

I do not purpose in this review to deal critically with the philosophy of the poem but rather to note the explanations offered of the various natural phenomena observed. We need not boast of our great knowledge of to-day but it becomes more precious to us when we realize how painfully and slowly it has been won for us, and how through centuries of darkness we have come to clearer light.

A word or two concerning the poem itself and its author may not be amiss. Lucretius lived somewhere in the last century preceding the birth of Christ and the poem was published about the middle of that century. An Epicurean in philosophy, and a follower of the atomic school of Demokritos, his poem was written as an exposition of their systems and in their defence. It was intended to explain to the minds of men the true nature of things and free them from ignorance and superstition.

Perhaps the most striking feature of Lucretius' poem is the deep reverence shown in it for the majesty of nature. The greatest minds were those which interpreted nature and the divinest faculty possessed by man was that through which truth was discovered. Homer was to him preeminent among the poets because he was near to nature and her great interpreter.

Prof. Sellars has said of him:

"It is, however, in his devotion to truth that Lucretius more than in any other quality rises clearly above the level of his countrymen and his age. He thus combines what is greatest in the Greek and Roman mind, the Greek order of inquiry and the Roman manliness of

heart. * * * He unites the speculative passion of the dawn of ancient inquiry with the real observation of its meridian; and he has brought the imaginative conception of nature that gave birth to the earliest philosophy into harmony with the Italian love of the living beauty of the world."

This poem is, as Constant Martha calls it, the most ancient monument of the science of Rome.

Lucretius had the difficult task of transcribing the concise, dry philosophy of Epicurus into the language of a people who knew little of science and cared less for it, except in the form of some useful application, and it required great ingenuity to succeed in conveying the desired ideas in a language so deficient in the needed terms. There is perhaps no great originality shown by Lucretius in the subject-matter of the poem but his enthusiasm and intense admiration for his master made him throw his whole poetic spirit into the task and so to give life and vivacity to the dry bones of the system. With a truly Roman simplicity, as Martha says, he believed that he and his master had said the last word of science. He was confident that his theories had solved all the mysteries of the universe, many of which were after all but the creations of superstition and trembling ignorance. A similar statement is made triumphantly nearly twenty centuries later by Berthelot. In the preface to his *les Origines de l'Alchimie* he too maintains that science has done away with mystery. "*Le monde est aujourd'hui sans mystere.*" We smile at the solutions which Epicurus, through his devoted follower, offered of the phenomena of nature. Who can feel assured that some future generation shall not smile, with the same pitying superiority, over the ignorance and folly of Berthelot.

"But the old problems that have defied the thought of the ages still wait for a solution. When men inquire for

the origin of matter and how it is constituted, or for the origin of force and how it operates, the sphinx is dumb. When they attempt to get behind the phenomena of heat, electricity, magnetism, they are challenged by a sentinel they can not bribe nor force." *

On an examination of this poem the essential difference between the ancient scientific method and the present is revealed and with it the reason for much failure and little progress. Lucretius first announced his theory and then proceeded to fit it, forcibly if need be, to every fact that came within his observation. This process is reversed by the modern man of science. He first gathers his facts and from their study develops his theory. A mind already full cannot receive new truth. The emptied vessel is the only one which is ready for filling.

To the mind of Lucretius the "Universe is a real exististence and absolutely dual in nature. Body and space, or matter and vacuum, are the two essential elements admitting no third. Bodies, are therefore, made up of atoms and pores. Neither can exist where the other is. The atoms are composite, yet, paradoxical as it may seem, are solid, single, indivisible and indestructible."

> Know, then, the entire of Nature sole consists
> Of Space and Body: this the substance moved
> And that the area of its motive power.
> Know, too that bodies, in their frame consist,
> Part of primordial atoms uncombined,
> And part combined and blending: these alone
> Previous and rare; while those so solid formed
> No force create can sever, or dissolve.

Now the task which Lucretius sets himself is to take this theory and by means of it explain the formation of the material world without the introduction of any creative intelligence, the genius of man and animals, the causative forces in all the natural phenomena and even

* Harrington. Meth. Quart. Rev. 1876. LVIII. 64.

the nature of such things as heat and light and of thought itself. In fact it is concerning the "nature of things" that he writes.

Let us see first how Lucretius reasons away the difficulty that his atoms cannot be detected by the sight and so brought within the reach of examination.

Learn now of bodies which you must confess
Exist in things, but yet nowhere can see.
First when incited winds o'er ocean sweep,
Dispersing clouds, o'er whelming mighty ships,
* * * * *
Thus secret bodies sure exist in winds
Which sweep the sea, the land, the clouds of heaven.
* * * * *
So various odors we perceive in things,
Yet naught material see the organ strike.
Nor heat, nor cold, nor sounds, can eye discern,
Though all of corpor'al nature must consist,
Since they the senses strike; for know, bodies
Alone can bodies touch or touched be.

Book 5 p. 46.

Again he very beautifully impresses the lesson, which he himself so imperfectly learned, that we must reason as to causes from their visible working.

Caverns deeply worn,
Where rocks impend o'er the corroding sea,
Show not the gnawing of each breaking wave:
For Nature acts on atoms hid from sight,
In secret working, but results reveals.

Book I p. 47.

See what proof he offers as to the existence of voids in matter. This was a very essential part of his theory and it is easy to see how convincing the phenomena must have seemed to such a materialist as Lucretius:

A void exists in things.
However solid bodies may appear,
Void spaces they contain, since water drips
In caves and grots, and drops ooze out from rocks,
And all around with trickling moisture weeps
Sound traverses closed doors and solid walls
While stiffening cold strikes piercing through the limbs.
But were no void how could such bodies pass?
You needs must see it were impossible. Book I p. 48.

His explanation of the difference in the specific gravity of various bodies is based upon this theory of voids.

> Why do some things excel in weight others
> Of greater size? If equal matter be
> In globe of wool and lead, why equal not
> In what to matter most essential is—
> Weight? Downward pressing to the void unknown,
> The greater lighter than the less, thus prove
> Existence of a void, the heavier still
> Embracing less than light of spaces void.
>
> Book I p. 49.

From his standpoint the weight was dependent upon density or compactness. From this is it might be inferred that all atoms had the same weight.

The beautiful phenomenon of the condensation of moisture upon a cold surface is correctly explained if we disregard the description of a material nature and separate existence to cold.

> Cold permeates the silver cup or gold,
> With water filled, held brimming in the hand,
> And dew-like moisture gathers on without.
> Thus naught in nature solid seems to be.
>
> Book I p. 53.

The doctrine of the indestructibility of matter has been commonly accredited to Lavoisier but a recent writer has shown that the saying attributed to him "*Rien ne se perd et rien ne se crée*" does not occur in his works and that at best he tacitly assumed this which had long been believed by others. Kahlbaum traces it to P. Mersenne the friend of Descartes but, it is easy to go many centuries back of this and to find the doctrine clearly stated in Lucretius. He writes of his atoms:

> Nature reserving these as seeds of things,
> Permits in them no minish nor decay;
> They can't be fewer and they can't be less.
>
> Book 1 p. 57.

Or again:

Decay of some leaves others free to grow
And thus the sum of things rests unimpaired

Book II p. 79,

And again:

The store of elements material,
Admits no diminution, no increase;

Book II p. 86.

No modern scientific man could state more clearly than Lucretius does, the ideas which prevail at present as to the motions of the atoms. Says Tyndall of the particles in a mass of iron: "There is space between them, they collide, recoil, they oscillate."

The poet states it thus:

No place of rest is found
To primal bodies through the vast profound,
And, finding none, they cease not ceaseless rounds.
Part forced together, wide asunder leap;
From closer blow part, grappling with their kind,
In close affinities unite and form
Bodies of various figure—varied forms diverse.

Book I p. 80.

Again:

For infinite atoms, in a boundless void,
By endless motions build the frame of things.

Book II p. 82

All things are made up of these atoms:

The same elements constitute the air,
The sun, the earth and animals and plants,
And other things by union various.

Book I p. 63.

Lucretius makes much use of what he calls the "seeds of heat," that is, the atoms which by their concurrence form heat. Thus he explains the heat resulting from friction.

The neighbor top of trees swayed by the wind
Are creaking rubbed, till by attrition they
Burst into flower of flame; not that the fire
Dwells in the wood but rather seeds of heat

By friction forced to flow, together run,
Aud bursting barriers fire the leafy tops.
For sure, if latent lay the flames in wood,
Not long could they be hid, but, bursting forth,
Would ravage forests, burning every shrub

Book I p. 63.

He is an avowed opponent of the ordinary view of gravitation. In common with his countrymen, he thought lightly of mathematics.

Guard agaist belief
Of what some say, "that to the centre tend
All things, and thus the world can stand
Without external impulses and shocks."—BookI, p 71.

Are we to look upon the following passage as a prediction of the discovery of argon and its strange companions? Speaking of his atoms he says :

And some there are wide wandering in space,
That all affinities reject, nor can unite
With any body in a common bond.—Book II p. 81.

He puzzles over one of our deep problems, the co-existence of sovereign law and the free will of the creature.

Again, if all motion in a chain were bound,
If new from old in fixed order flowed,
Cause linked to cause in an eternal round;
If atoms no concealed clinamen had
Cause to create, and break the bond of fate,
How could free-will in animals exist?

In speaking of the dissimilarity in atoms he discusses the nature of fire and cold. His conclusions are somewhat startling :

How different is fire from piercing frost!
Yet both composed of atoms toothed and sharp
As proved by touch. Touch, O ye sacred powers!
Touch is the organ whence all knowledge flows:

Book II p. 90

His theory as to the three physical states is that solids are made "of atoms hooked like branches deep entwined"; liquids, "of bodies round and smooth must be composed";

"while those that in an instant are dispersed, and flee away, as smoke, or clouds, or flame," are formed of "sharp and not of atoms hooked since pores they penetrate."

The dependence of color upon light is well recognized "without light no color can exist." Atoms are colorless and not subject to the rays of light,

He has noted that

> The more minutely things divided are
> The more their colors fade.

He has observed that light traverses space more rapidly than sound,

> Far quicker comes the impulse to the eye
> Than to the ear:
>
> Book VI p. 263.

There is an interesting passage in the works of Van Helmont in which he describes the artificial generation of mice from a soiled shirt placed along with some flour in a barrel or other vessel. The method sounds plausible and doubtless an experiment along that line would result in mice in the barrel. But too much credit must not be ascribed to Van Helmont as the original discoverer for after all his ingenious idea was not original. Our poet of the last of the old centuries says;

> Facts manifest
> Confute not but confirm and force belief,
> That all the living from the lifeless springs;
> For see live worms creep from the putrid clod,
> When the warm earth is wet with timely showers.
>
> Book II p. 106.

Darwin might have gotten an idea or two from our ancient philosopher for his "Observations upon Earthworms".

Lucretius' ideas as to life, disease and death are also instructive. Men of deeper learning than he have wrestled with this problem of Life and Death with equal

failure. The best of modern thought agrees with him in one sense at least when he says:

"And life itself is but a part of death."

Death he believes comes from some shock which shatters and destroys the union of the atoms. The shock theory of fermentation and decay was vigorously maintained and defended during the first half of this century.

Then when some greater shock a life assails
Than Nature can support, sudden all sense
Of mind and body is confused and stunned.
The ordering of elements dissolved,
Their bond of union snapped, the silver cord
Is loosed, the vital tide turned back, and life
With all its elements dispersed. But what
Can blows do more than shatter and dissolve
What once was joined?

Book II p. 108

Liebig in 1852 reasoned that contagion was due to gaseous matter in a state of decomposition. Disease is excited by contagion. According to the "law of La Place and Berthollet: *A molecule* set in motion by any power can impart its own motion to another molecule with which it may be in contact. The motion of these decomposing molecules is transmitted to the blood and if decomposition there is not overcome it proceeds over the entire body." This reads almost as strangely as the words of Lucretius. It is only just to Liebig to add that he acknowledged his errors afterwards and accepted the theories of Pasteur and Schützenberger.

Lucretius' theory of contagion would sound very much like the modern germ theory if only his seeds were endowed with life.

First, then the air teems, as I've taught, with seeds
Diverse, some favoring life, but many more
Fraught with disease and death; chance gathered, these
Infect the sky, malignant make the air.

Lucretius has anticipated the recent address of Sir

William Crookes, the learned President of the British Association for the Advancement of Science, by more than nineteen centuries in the prediction of the exhaustion of "the worn-out Earth." True he did not fix upon 1931 as the date of complete exhaustion still he evidently did not think it very far off. Like all sturdy conservatives he praised the good old times.

E'en now the worn-out earth with age effete,
* * that in her early prime * * *
To children of her care spontaneous gave—
In rich abundance gave the shining grain,
Which now with labor huge she scant supplies
In niggard pittance to more pressing wants,
With weary steps we urge the weary ox,
And turn exhausted fields, that scarce return
Decreasing harvests to increasing toil.
The aged ploughman shakes his weary head
So oft his labor unavailing proves:
How oft doth he then repining chide his lot
Comparing present times with past, exalt
The fortune of his sires.

Book. II p. 114.

He gives a remarkable explanation of the nature of reflected images. These are made up of

Thin effigies and forms
Which singly are unseen; but when outpoured
In a continuous and impulsive flow,
Give by reflection, images of things.

These effigies "wander not alone." They "fill the embracing air with floating forms." This is proved by the fact that in whatever direction the mirror is turned, "straight in its silent depths the scene responds." The reversal of the image in the mirror is explained at some length. The image itself suffers change on turning back from the mirror.

As when the plastic mask of wax, or clay,
Dashed sudden 'gainst a wall, backward reverts,

The well-recognized law that the angle of reflection is equal to the angle of incidence comes from Lucretius thus:

For with what slope
They fall, Nature compels them to revert again.

Peter Schlemihl, the famous shadowless man of Chamisso would have been wondrously relieved if he could have read Lucretius and learned,

The obsequious shadow that attends our steps,
When walking in the sun seems of itself
To walk with us and every gesture mock
Yet nothing is but space, deprived of light

Book IV p. 169.

If we accept Lucretius' theory that "all sounds corporeal are," then it is easy to account for prevalent sore throats·

And voice escaping to the sphery air,
Roughens the throat, abrades the passages.

"Whence come our mental images" is surely a most important question to settle but one before which the boldest is apt to hesitate.

There is no such hesitancy about Lucretius, however. "Innumerable idols float in space." These are many subtle and of finer texture than the "attenuate thread of spider or the roof of filmy gold." These

Through rarer pores can penetrate.
And sentient make the mind in inmost seats.

Book IV p. 181

Any one inclined toward materialism can read with interest the intense materialsm of this old Epicurean. His cosmogeny is brilliantly fanciful. As to the sun it is neither greater nor less than it appears and this is true also of moon and stars. Whether the sun returns by a course beneath the earth or whether it is exhausted by its day's course and its place is taken by a new one, formed by the collection of "dispersed seeds of heat" he does not venture to decide. Eclipses and the moon's phases are also discussed. The struggle for existence is pictured and something very similar to the doctrine of the survi-

val of the fittest is announced. Thunder is the rushing together of several clouds "driven by warring winds." The nature of clouds he discusses at great length. Some of these phenomena have puzzled men all through the ages and it is not nccessary to point out how imperfect our knowledge still is.

The interior of the earth is constituted as the surface and hence contains caves, lakes etc. The falling in of such caverned depths cause the earthquakes. In these caverns the air in motion "makes glow the rocks around." Winged flames then "vomit from wide open jaws" hurl rocks, and send out cinders and smoke, and so volcanoes are formed. The constancy of the volume of the sea was observed by Lucretius and correctly accounted for.

A strangely mistaken observation as to the temperature of wells is mentioned and of course his theory is made to cover and explain it. Such waters were thought to be cold in summer and warm in winter. This was, of course because what we may call the personal thermometer registered largely the relation to the temperature of the atmosphere.

I have not been able to exhaust all of the observations recorded by this early philosopher, nor to properly show his ingenuity in fitting his theory as to atoms and the "seeds of things" to every case. Nor has it been possible to give a just idea of the grace and poetic beauty of this the first and only attempt to bring all of natural science within the limits of a single poem.

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6 Lucretius, by Prof. Harrington, Methodist Quarterly Review- 1876, p, 64.

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FIFTEENTH YEAR——PART SECOND.

1898.

ON THE FEASIBILITY OF RAISING SPONGES FROM THE EGG*

H. V. WILSON.

For the purposes of scientific investigation the problem suggested in the title of this paper presents no difficulties to the zoologist. Whether, on the other hand, it is practicable or even desirable to rear sponges from the egg for the purposes of the sponge-grower, is a question which can only be decided by experiments carried on continuously for some years. From the standpoint of the scientific breeder such experiments seem eminently desirable, and the probability that they would result in economic discoveries of importance is very great. It is my purpose to point out, toward the end of this paper, some of the advantages attainable, as I believe, by this method of breeding. I shall preface my remarks on the rearing of sponges with a brief account of the manner in which the egg development goes on.

*Extracted from "Proceedings and Papers of the National Fishery Congress held at Tampa, Fla., Jan. 1898," published in Bulletin of U. S. Fish Commission, Washington, 1898.

Some sponges are known to be hermaphrodite, others have been described as of separate sexes. The probability is that sponges are in general hermaphrodite, but that the individual at one period produces chiefly male elements, and later chiefly female elements. Fertilization takes place in the body of the mother and the egg here undergoes early development. The embryo eventually bursts the maternal tissue, and, passing into one of the canals, is caught by the current sweeping through the canal system and is discharged into the surrounding water through one of the large apertures (oscula) on the surface of the sponge.

In the great majority of sponges (horny and silicious forms) the embryo, or larva as it now should properly be called since it leads a free life, is an oval, solid body, covered with slender hair-like processes of protoplasm, the so-called cilia. The cilia strike rythmically to and fro, like so many minute and flexible paddles, and the sponge larva is by their means whirled through the water. Sponge larvae, of course, vary in size, but frequently have a length in the neighborhood of 1 mm, (.04 inch). The surface layer contains more or less pigment. Thus in the commercial sponge, *Euspongia*, the larva is whitish, with a brown spot at one end. In *Tedani brucei*, a large red sponge, growing especially on the mangroves in parts of the Bahamas, the larva is a beautiful red.

The free swimming life of the sponge larva is short lasting, when bred in the laboratory, only a day or two. During this period the larva is moved not only by its own relatively feeble motion, but, being subject to the action of the currents, it may be carried a considerable distance from the spot where it was born. It eventually settles down on some firm basis and transforms. The cilia are lost, and the oval body flattens out into a disk so thin that it

has the appearance of a minute incrustation. The circular outline of the disk is soon lost, the little sponge spreading in an irregular fashion over the surface to which it is now firmly attached. In two or three days the metamorphosis is complete, and we have a sponge, very small to be sure, and without reproductive elements, but like the adult in fundamental structure. Its surface is perforated by minute apertures, the pores, through which the water enters the body, and by a few larger apertures, the oscula, through which the water leaves the body. Ramifying through the interior is a system of spaces or canals which connect the pores with the oscula. Portions of this canal system form spheroidal chambers, the walls of which are studded with cilia. It is owing to the motion of these internal unseen cilia that a current of water is constantly circulating through the sponge body, carrying to its tissues the oxygen and food (minute particles of animal and vegetable organisms) necessary for their life.

How long it takes for a sponge developed in this way to reach adult size and begin breeding is unknown. I have kept young sponges that have transformed and attached to the walls of my laboratory aquaria for days and weeks. After the first few days the increase in size has generally been imperceptible. But the unfavorable conditions incidental to such an unnatural habitat were doubtless responsible for this lack of success.

PRACTICAL SUGGESTIONS ON REARING SPONGES

More species of sponges breed during the warm season than at other times. Yet in the Mediterranean (Naples) some sponges are found breeding at all times of the year. In the Bahama Islands and on our own coast, I have found the breeding time of many sponges to fall within the period from midsummer on through early autumn. For

the inauguration of experiments I should reccommend the months of July, August, and September.

It is easy to determine when one of the horny or silicious sponges is breeding. On cutting out a piece of the sponge, the developing eggs scattered though the tissues can be seen without the help of a lens. They are minute, rounded bodies, often very numerous, and sufficiently conspicuous to catch an observant eye.

The means employed for getting young sponges must always be different from those made use of in the case of animals like fish, oysters, etc., in which artificial fertilization is practicable. Since the sponge egg is fertilized and undergoes its early development in the body of the mother, artificial fertilization is here of course out of the question.

The young in numbers ample for study can, however, be obtained in the following easy manner. The sponge being raised to near the surface of the water is then dipped up in a glass aquarium or bucket, in such a way as not to expose the animal to the air. In a few minutes time the ciliated larvae will begin to be discharged. In the study of some Bahama sponges I found it convenient to take to the sponge-grounds, in a boat, a couple of good sized tubs. In one of these some sponges would be placed for about half an hour. At the end of that time they were transferred to the second tub. The water of the first tub was meanwhile examined for the sponge larvae. In this I was aided by negro boys, who soon became expert. We bailed out the water in 2-gallon glass vessels in which the little larvae could readily be seen. The latter were then picked out with glass tubes and placed in a special dish. By the time the examination of the first tub was completed, the second would be found to contain numbers of larvae. These were collected in the same way, the sponges being thrown overboard.

It would seem in the case of sponges, as with so many marine animals, that the stimuli arising from confinement in a limited volume of water lead to the rather sudden discharge of those embryos (or in certain forms, eggs) that have reached the proper stage for birth.

I have no doubt that if the sponge were handled carefully, it would be possible to get from the same individual, day after day during the breeding season, numbers of larvae, precisely as several batches of eggs are got from one codfish, for example.

The swimming larvae thus obtained may be made to attach, during the next day or two, to the walls of the dishes in which they are kept, or to pieces of wood or small stones. After attachment the young, or, as we might say, the sponge "spat," are easy to handle. In this connection, however, it will be well to bear in mind that the circulating pipe water of aquaria, even large and elaborate ones such as those at Naples and Woods Holl, has been found to be unsatisfactory for the rearing of young sponges, as indeed it is for the young stages of many marine organism. The sponges become covered with sediment, and bacteria develop. Changing the water in the dishes twice a day is, on the whole, a better method. But this is far from an ideal environment. It will probably be much better, after the attachment of the spat to pieces, of wood, shells, etc., at once to transfer the latter to some natural site known to be adapted to the growth of sponges.

I hardly think the method of getting young sponges which I have just described can ever be adapted to the needs of the sponge-grower. And yet for the purposes of experiment, where a few hundreds or a thousand young sponges would suffice, the method is adequate. I believe, however, that live-boxes may be devised in which the sponge may be kept imprisoned in its natural home,

though at some convenient depth, and in which the discharge of larvae may go on normally day after day. Such a box must have fine metal gauze windows on the sides and above, through which water may pass freely, and yet with meshes sufficiently fine at any rate to hinder the passage of the larvae through them. Projecting shelves, which must be easily removable, might be arranged one above the other. The sides and bottom of the box should, moreover, be covered with removable pieces—tiles, for instance. The larvae settling down on the removable shelves or other pieces would attach to them, and might from time to time be taken out with as much ease as the honey stored up in the modern manufactured comb; is removed from the hive.

The precise form of live-box to be used will naturally only be determined after proper experiments. To prevent as far as possible the settling of the larvae on the body of the mother, a phenomenon very apt to occur, it will perhaps be found well to place the adult on a perforated tray near the top of the box, and a series of such trays, one above the other, may be found a good device. In planning experimental boxes of this sort, the character of the motion of the sponge larva should be borne in mind. The larva not only swims, frequently making long, shallow dives, but also creeps about over the sides and bottom of the vessel in which it is kept.

The live-box has proved itself of great use to the naturalist desirous of obtaining the young stages of animals, which are difficult to keep or breed in the laboratory. In this connection I well remember the experience of a companion (Prof. C. L. Edwards), engaged in the study of the development of the large holothurian or sea-cucumber (Mülleria), so common in parts of the Bahama Islands. It was with the greatest difficulty that a few embryos of this form could be got in the laboratory.

When, however, the animals were confined in a large box anchored in about a fathom of water, quantities of developing eggs could be had by drawing up with a tube some of the sediment in the bottom of the box.

The "spat" ouce obtained in abundance, success will next depend largely on the selection of the locality in which the young sponges are to be set out. A careful study of the Florida grounds should be undertaken, with the view of investigating, among other points, this very matter of the kinds of locality best adapted to the growth of the various grades of sponges. Quiet water, a firm bottom, and an absence of muddy sediment seem essential desiderata. The question of enemies is probably of minor importance, and yet the well-known student of sponges, Vosmaer, mentions that he has several times seen the European hermit-crab (*Pagurus*) greedily eat a common silicious sponge (*Suberites*), certainly quite as unappetizing a morsel as the commercial sponge.

When it has once been accurately determined what are the physical and biological characteristics of the Florida grounds, which produce the finest sponges—and it may be mentioned here that sponges are among the most variable of animals and seem to be peculiarly affected by their surroundings—a detailed comparison should be made between these grounds and those parts of the Mediterranean producing the finest grades. The purpose ofsuch a comparison would be to discover whether we really lack any of the natural advantages necessary for the production of the finest sponges, and if so, whether these can be artificially reproduced—whether for instance it would be possible or desirable to imitate on this side a particular kind of bottom found in the Mediterranean.

Following on the investigation of the sponge-grounds,

I believe it to be eminently desirable to start a series of of experiments, the purpose of which shall be to discover how far, along what lines, and by what means sponges may be artificially altered by breeding. The great variability of sponges in nature leads one to believe that they would quickly respond as individuals to a change in the environment, and thus, simply by growing the animals in a superior locality, an improved variety, constant, as long as the sponges continue to grow in that locality, might be produced. It is quite likely that such improvements could be carried out on sponges propagated by cuttings as well as on those grown from eggs. In improving races, however, it has always been found that the two important means are sexual breeding from selected specimens, and grafting, the latter method being commonly regarded as only applicable to plants.

In the case of sponges, as in that of other organisms, increase of knowledge will in all probability confirm the belief already fairly well grounded, that individuals developed from the fertilized eggs vary more, i. e., exhibit more differences one from the other, than individuals grown from buds or cuttings. Herein, to my mind, lies the advisability of growing sponges from eggs as well as from cuttings. The latter method, being quick, sure, and simple, can at once be made of great practical use. Breeding from the egg is more complex, and must be carefully tried by competent experimenters. In the end, however, I believe that it will lead to great improvements in the quality of our sponges.

I would suggest that, after selection of a proper locality, a small plantation of sponges developed from eggs be started and carefully watched. As the sponges grow, it would be a simple matter to pick out those individuals in which the fiber varied in the desired direction. A small

piece cut out would not seriously injure the sponge, and would show the quality of fiber as well as the entire body. Selected individuals might be removed from the general ground and during the breeding season placed together in large live boxes. The "spat" collected from such individuals would doubtless develop into superior sponges. I do not know any marine animals which would seem to be so adapted to continuous rearing, with constant improvement of breed, as sponges. Their plant-like habit of growth make it easy to handle and experiment upon them. Their variability, especially in the matter of the skeleton, would seem to insure success to selective breeding; and the very simplicity of what is desired, namely, improvement in the quality of the skeletal fiber, would at once lend a directness to the cultivator, which should lead to comparatively early results.

In closing, I may direct your attention to a method of race improvement, so far practiced only in the cultivation of plants, but to which the vegetative character of sponges will readily lend itself. I refer to the method of grafting. The ease with which two or more individuals of the same species of sponge, irrespective of age, may be made to fuse, and become henceforth a single individual, is well known. Dr. Grant records observations on this head as far back as 1826. Among later experimenters I will only mention Vosmaer. This fusion of individuals goes on commonly in nature. An interesting account of a number of cases may be read in Johnston's British Sponges and Corallines, published 1842, page 11.

The natural tendency of sponges to grow together, coupled with the ease with which they may be propagated by cuttings, would make artificial grafting in these animals a simple matter. With a small plantation of very superior sponges at hand, the result of careful breeding from selected individuals, and other plantations consisting fo

sponges grown from cuttings, grafting ought to be not only a scientific but an economic success. At slight expense large numbers of common sponges might be improved, simply by pinning to the common cutting a piece of the improved varietv.

A REVIEW OF CONANT'S MEMOIR ON THE CUBOMEDUSÆ*

H. V. WILSON.

Memoirs from the Biological Laboratory of the Johns Hopkins University, IV., 1. *The Cubomedusæ*. A Dissertation presented for the Degree of Doctor of Philosophy, in the Johns Hopkins University, 1897. By FRANKLIN STORY CONANT. A Memorial Volume. Baltimore, 1898.

The late Dr. Conant, it will be recalled by many, was a member of the marine laboratory of the Johns Hopkins University, stationed during the summer of 1897 at Port Antonio, Jamaica. Toward the end of the season's work fever broke out. The director of the expedition, Dr. J. E. Humphrey, died in a sudden and alarming manner. Dr. Conant assumed charge of the laboratory, and, though aware of his own great danger, remained in Port Antonio, devoting himself to the service of others who needed his help. This generous subordination of self cost him his life, for he contracted the fever, and, though able to reach this country, he died a few days after his arrival in Boston.

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Dr. Conant's many friends, well aware of his candid, judicial mind, his keenness and persistency in observing and in reasoning from observations to a conclusion, have entertained the highest expectations of the work he was to do for science. Cut off at the beginning of his career, he leaves behind him several smaller papers and the dissertation before us. On closing this volume the author's friends will feel confirmed in their high opinion of his abilities, and those who did not know Dr. Conant will realize with regret that an able and conscientious naturalist has been removed from our midst.

Dr. Conant's dissertation, published as a memorial volume by his friends, fellow students and instructors, with the aid of the university in which he had recently taken his doctor's degree, deals with the anatomy and classification of one of the most interesting groups of jelly-fish, the Cubomedusæ. In this group, embracing but a small number of species, the scyphomedusan structure, with which most of us are chiefly familiar through the study of *Aurelia*, *Cyanea* or *Dactylometra*, is in general presented as destitute of the complications which characterize the more common forms. This simplicity in general structure places the group close to the stem-forms, *Tessera* and *Lucernaria*, themselves scarcely more than sexually ripe *Scyphistomas*, and makes a comparison with existing Actinozoa an easy matter. Curiously enough, the members of this primitive group possess the most highly developed sense-organs as yet described among coelenterates, the nervous system being correspondingly differentiated. In one other respect the Cubomedusæ are unique, in that they alone among the Scyphomedusæ possess a velum. The phylogenetic origin of this velum (velarium) has been the subject of some discussion, the balance of opinion inclining to the belief that it has arisen through the fusion of marginal lobes similar to those

found in the Peromedusæ and the Ephyropsidæ (*Nausithoë*), and is merely analogous to, not homologous with, the velum of the Hydromedusæ. That this is the case is borne out by the presence in the velum of gastrovascular diverticula. This resemblance to the Hydromedusæ is regarded by most naturalists as one of the numerous cases of convergent evolution exhibited by the two groups of jelly-fish (Hydro- and Scyphomedusæ), due to similarity in environment and to a certain similarity in the ancestral polyps from which the two groups have been derived.

The Cubomedusæ are so rare that in spite of their interesting features, interesting alike to the student of phylogeny and nerve-physiology, few naturalists have had the opportunity of studying them. Our knowledge of the group has rested mainly on Claus's description of *Charybdea marsupialis* (Wien. Arb. 1878). This very valuable paper, as Conant remarks, is written in a style difficult of comprehension, and many students who read with pleasure and profit the lucid treatises on medusan structure by the Hertwigs and Haeckel have turned away discouraged from Claus's work. To Claus's account, Haeckel in his "System" has added but little. The only other investigator of the group is Schewiakoff (1889), who has studied the remarkable sense organs.

Through Conant's discovery in 1896 of two new species (*Charybdea Xaymacana* and *Tripedalia cystophora*), which are present in abundance in Jamaican waters, the Marine Laboratory of the Johns Hopkins University has once again made accessible to students, material for the pursuit of investigations of wide interest. It was for the purpose of continuing his study of this group that Conant, in the summer of 1897, revisited Jamaica, and, as we learn from Professor Brooks's introduction, he succeeded in making many observations on the physiology of the

sense-organs and on the embryology. His notes and material, we are told, are in such shape that they can be handed over to some else, and it may be safely predicted that a valuable contribution to science will be the outcome of the last summer's work of this talented young naturalist.

The account of the cubomedusan structure given by Dr. Conant is succinct, but comprehensive. The deep, four-sided bell bears a tentacle (or in some species a bunch of tentacles) at each angle. On each lateral surface, at a higher level than the tentacles, is situated a niche into which projects a sense-organ. The primitively undivided (Scyphistoma condition) gastrovascular space is here differentiated into a central stomach and a peripheral portion lying in the lateral wall of the bell. The peripheral portion is subdivided into four stomach pockets by linear partitions, lying in the plane of the tentacles and therefore interradial. These partitions (cathammæ) are mere strips of entodermal lamella, produced by the fusion between the entodermal lining of ex- and sub-umbrella. The cathammal lines stop short of the tentacles, leaving an undivided peripheral portion of the primitive space, by means of which the four stomach pockets communicate with one another. As Conant points out, the arrangement recalls the gastrovascular system of many Hydromedusæ, with the difference that in the Cubomedusæ the radial canals are wide 'stomach pockets' and the cathammal plates are narrow lines. When we come, however, to the extreme peripheral portion ol the gastrovascular system, we find that the likeness is not with the Hydromedusæ, but with the lobed Scyphomedusæ. The gastrovascular space, to be brief, does not end with an even circular edge at the bell margin, as is the rule in the former group, but is divided into separate lobes (marginal

pockets) extending into the velum (as velar canals). Conant does not dwell on phylogenetic inferences, but evidently inclines to the belief that the ancestors of the Cubomedusæ possessed a margin divided into sixteen lobes. The present position of the four sense organs indicates the site of the original margin, "which elsewhere has grown down and away from its former level, leaving the sensory clubs like floatage stranded at high-water mark." Fusion between adjacent lobes, involving the ectoderm and jelly, gave to the medusa a continuous margin and a 'velum', but, owing to the incompleteness in the fusion of the *entodermal linings* of the several lobes, the latter still retain in the adult Cubomedusa enough of their individuality to indicate their former condition. In a word, the marginal pockets of the existing Cubomedusæ are to be construed as entodermal linings of once separate lobes.

This conclusion as to the morphology of the marginal pockets derives much support from the behavior of a puzzling structure, called by Conant the marginal lamella. Unlike the true vascular lamella, which simply connects one entodermal cavity with another, the marginal lamella extends from the entoderm of the gastrovascular space to the ectoderm of the bell margin. It is a narrow strip which follows the outline of the marginal pockets, traveling in the radii of the sense organs far away from the actual edge of the bell, and surrounding the sense organs in such a way as to indicate clearly that they were once at the bell margin. The marginal lamella seems to be a functionless, rudimentary organ. Claus, whose imperfect description of the structure did not bring to light its morphological interest, as indicating the site of the ancestral bell margin, suggested that it was perhaps the vestige of a ring canal. Conant naturally is skeptical of this explanation of a lamella connecting ento- and ectoderm. The true meaning of this peculiar lamella is a

point well worth working up, more especially as it is not confined to the Cubomedusæ, but has been observed in the ephyra lobes of discophores (*Rhizostoma*).

Before leaving this subject of the general body-plan, it may be mentioned that while the probability is that the Cubomedusæ are descended from stalked ancestors (*Lucernaria*-like forms), and hence that the apex of the exumbrella was once drawn out into a peduncle, there is in the adult Cubomedusa no trace externally or internally of this hypothetical stalked condition. Light on this very interesting point can only be expected from a study of the development.

Unlike the other Scyphomedusæ studied, the Cubomedusæ possess a nerve ring. In their study of the nervous system Claus and Conant both depended on sections, and naturally the results are not so satisfactory as those reached by the Hertwigs on the Hydromedusæ mainly with the aid of macerations. Claus describes the neuro-epithelium as consisting of alternating supporting cells and sensory cells, the inner ends of the latter becoming continuous with the nerve fibres. Conant makes it doubtful whether this is the actual condition, since he does not find the sensory cells. He offers, however, no observations on the origin of the 'nerve fibres.' Macerations will probably show the connection of these fibres with at least some of the neuro-epithelium cells.

The possession of a nerve ring has been regarded (Claus) as a point of essential similarity between the Cubomedusae and the Craspedota. The main ring in the former group is obviously a differentiation of the subumbrellar epithelium, and Claus, therefore, interprets it as homologous with the inner Craspedote ring. In the immediate neighborhood of each sense organ there are given off from the main ring two roots which *ceasing to be superficial bands* pass through the jelly, and emerge on the outer wall

of the bell (on the floor of the sensory niche). They converge and unite, forming a superficial nerve tract which crosses the base of the sense-club. These four isolated tracts are regarded by Claus as the remnants of a once continuous exumbrellar ring, such as is found in the Hydromedusae, and which here, as in the Hydromedusae, stands in connection with the subumbrellar ring through the medium of fibres that perforate the jelly. Conant, on the other hand, regards the tracts lying across the bases of the sense organs as portions of the primitive subumbrellar ring which were shut off from the main ring, when the marginal lobes grew together. With the Hertwigs and Haeckel he thus looks on the ring as not homologous with that of the Craspedota, but as a special differentiation of the subumbrellar plexus found throughout the Scyphomedusae.

The sense organs of the Cubomedusae are 'sense-clubs' or modified tentacles. In addition to the crystalline sac, the expanded head of the club bears six eyes. Four of these are simple, but two are complex organs provided with a cellular lens and cornea, a vitreous body behind the lens, and a retina. These eyes look into the bell cavity. It is especially in reference to the structure of the retina and vitreous body of the complex eyes, that Conant's conclusions differ from those of Schewiakoff. The vitreous body Conant finds is not a homogeneous structure, but is composed of prisms of refracting substance. The retina does not show the two types of cells (sensory and pigmented) distinguished by Schewiakoff. Conant's results in this matter of the retinal structure are in some respects negative. The points still to be cleared up are as in the case of the nerve cord, such as will require the free use of macerations and surface preparations of fresh tissue.

DISTRIBUTION OF WATERPOWER IN NORTH CAROLINA.*

BY J. A. HOLMES.

The two conditions essential to the development of a waterpower of any considerable magnitude are a large and fairly constant stream of water and a suitable amount of fall within a reasonable distance. In the eastern counties of North Carolina we have numerous large streams of water, but, except along the western border of the region, as a rule they have sluggish currents and are lacking in the necessary fall. In the mountain counties the streams are small, but the fall available in many cases is sufficiently great to make possible waterpower of considerable magnitude. It is in the middle counties, however, that we find the most satisfactory combination of the two essential conditions, viz. volume of water and fall; and hence it is in these counties that we may expect the largest waterpower developments and the greatest and most substantial growth of manufacturing enterprises.

It is intended in the present paper to discuss briefly the distribution of these water powers in the State in their relation to geologic features, and the accompanyiny map (Plate I) will prove of service in this connection.

WATERPOWER IN THE COASTAL PLAIN REGION.

Along the western border of the coastal plain region there are a number of important waterpowers, like those at Weldon on the Roanoke, Rocky Mount on the Tar,

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and those on the Cape Fear as far east as Averasboro. These, though they lie within the limits of this region, yet structurally do not belong to it, and can best be considered under the next heading below, in which will be discussed the waterpowers which belong rather to the border zone between the coastal plain and the Piedmont plateau regions, and which can perhaps be best designated as the fall line zone.

With the exception of the waterpowers just referred to, it may be said of the coastal plain region as a whole, that its waterpowers are of no great importance. The water supply is ample but the fall is lacking. And yet there exist at many different points in this region conditions which are favorable to the development of waterpower which, though small, have considerable local value. Until a comparatively recent date, practically all of the grist mills in this section were operated by small waterpowers, and a considerable number of these grist mills are still in operation. But such water waterpowers were confined to the smaller streams, and in many cases the development of power consisted simply in the construction of a dam across the deep, narrow channel of the stream without the existence of a natural shoal, and the amount of fall is approximately the height of the dam.

The most striking feature about the waterpower developed on the majority of these smaller streams is the slight extent to which the volume of water is effected either by the rains or dry seasons. The most widely known illustrations of this condition are Rockfish creek in Cumberland county, and Hitchcocks creek in Richmond county, both of which though small are industrially important streams. The former with a drainage basin of 280 square miles, running five cotton mills, and the latter with a drainage basin of 102 square miles running six cotton mills. The explanation of

this phenomenon is to be found in the fact that the deep, porous sands of the region serve as a sponge in soaking up the rains as they fall, turning loose this water gradually during the dry season through numerous springs.

In the case of many others of the small powers in this region, as that on Colly creek in Bladen county and others in the different eastern counties, the uniformity of the flow throughout the year is favored by the further condition that the tributaries of these streams pass through extensive swamp areas which also serve to store the water for use during dry weather.

WATERPOWERS IN THE FALL LINE ZONE.

Along the "fall line" or the fall line zone in North Carolina there are conditions favorable for the development of waterpowers of considerable magnitude on our larger streams. And since the exact position of this fall line is not clearly defined, and as the conditions favoring waterpower development extend across a considerable belt or zone where this line is crossed by the larger streams, it is better in this connection to consider together these conditions as they exist at and for a few miles on both sides of this boundary line between the coastal plain and Piedmont plateau regions.

ON THE ROANOKE RIVER.

The conditions favoring waterpower development on the Roanoke river in this zone, which at this point has a width of about 9 miles, extending up the river from Weldon, may be considered as typical of those existing other points. Waterpower developments of considerable magnitude are now in progress on the Roanoke and are being planned on the Cape Fear and Yadkin.

In portions of the coastal plain region, however, where the streams are cutting their way down across the horizontal and soft strata such as alternate beds of clay and sand, we have conditions somewhat similar to those described above except that in these cases the strata, instead of being alternate layers of hard and soft rocks, are of altogether unconsolidated materials which have not yet turned to stone. Such a condition of things may be illustrated by fig, 1, which represents somewhat the conditions existing on Rockfish creek in Cumberland county.



FIG. 1.

FIG. 1.—Interbedded sands and clays favoring the development of rapids in river channels.

P and P′=Finely laminated and in places cross-bedded, black laminated clay below, and bedded but cross-laminated clayey arkose above, the strata of both clay and arkose being separated by layers of sand varying in thickness from a small part of an inch to several feet. The strata marked P′ above *rr* represent the same strata as P′ below the *rr*. *s*=Sand hills back from the stream border. *t*=River terraces of recent loams, gravel at their base. *rr*=Surface of the stream showing that as it washes away the laminated arkose and clay, irregular rapids are produced in the stream, owing to the more rapid removal of the interbedded sand.

In the lower portion of its course the waters of this creek have cut their way through the overlying sands and loams and are now cutting through the lower interbedded sands, clays and arkose, and the still lower more finely laminated sands and greenish-black clays. Near the mouth of Rockfish these materials in its bed have been worn away to the level of the Cape Fear river

which it joins. Further back from the Cape Fear the cutting down through alternate layers of loose sand and tough clay has resulted in producing a rapid but irregular current with occasional small shoals, at several of which waterpowers have been developed by the construction of dams and factories erected.

Figure 2 may be considered as illustrating fairly well



FIG. 2.

FIG. 2.—Conditions favoring the development of cascades and rapids in stream beds crossing geologic contacts.

gn=Granite and gneiss. *sch*=Crystalline schists, in which the harder places (shaded more heavily) wear away less rapidly than the intervening softer places. The result is a series of cascades and rapids in the stream. *p*=Coastal plain deposits—gravel, sand and loam.

a generalized section across the fall line where crossed by the Roanoke river at Weldon. The crystalline schists exposed along the river bed between Gaston and Weldon (G and W of fig. 2) are much harder and more obdurate than the unconsolidated coastal plain deposits below, and even harder than the granite and gneissic rocks above it; and hence the latter rocks have been eroded to greater depths, and at the line of junction between the two (1 in fig. 2) the schists form a sort of barrier or natural dam, for many miles above which the river is deep and the current sluggish. But from this point down to Weldon the schists vary in hardness, and are intersected by joints, seams, fissures and probably sev-

eral faults; this succession of variations giving rise to a succession of rapids and shoals, with an aggregate fall of 85 feet in a distance of 9 miles. For this distance the river flows through a deep and open gorge flanked by hills which, near Gaston and a short distance westward, are capped with unconsolidated gravels, presumably of Potomac age, and bordered by terraces of more recent age, probably post-tertiary (Columbia). In the neighborhood of Weldon and eastward the rocky hills give places to the terraces and plains of the coastal region, composed of gravels, sand, loams and clays, varying in age from Potomac at the bottom to Columbia at the top.

ON THE TAR RIVER.

On the Tar river there is but one large waterpower, that at Rocky Mount, which may be considered as being at the eastern margin of this zone and some 20 miles eastward of the western border of the coastal plain region. The Tar rises nearly 100 miles to the northwest of this point and crosses successively several granitic, schistose and slaty belts of rock, but owing to the slight elevation of this upper part of its basin above that of the coastal plain, the long period during which the rocks of this upper basin have been undergoing surface decay, and the long period during which this stream, with no great volume of water, has been slowly carving out its channel, its freedom at the present rime from conditions favorable to waterpower is easily understood. At Louisburg there is a fall of several feet owing to a change in the character of the granitic rocks. At Rocky Mount it turns eastward and crosses a ledge of hard granitic rock, on the eastern slopes of which there is a natural fall of about 15 feet in the course of 100 yards. It is on the top of this granite ledge that the dam has been built which serves for the full development of this waterpower for operating the Rocky Mount cotton-mill.

ON THE NEUSE RIVER.

On the Neuse river, as on the Tar, there is rather a remarkable absence of conditions favorable the development of large waterpowers. Of the two powers worthy of mention, both lie within the granite area, one to the north and the other to the north-east of Raleigh, and are due to local changes in the character of the granitic rock.

ON THE CAPE FEAR RIVER.

The fall-line zone on the Cape Fear river may be said to begin where this river is former by the junction of the Deep and Haw rivers, and to extend from that point to a short distance below Smileys falls, near Averasboro. In this distance of about 35 miles there is a succession of shoals beginning just above with Buckhorn falls, 9 miles below the junction of the two rivers, where there is a fall of 20 feet in a distance of one and one-half miles, while the lowest of the prominent shoals, "Smileys falls," 30 miles below the junction, has a fall of 27 feet in a distance of three and one-half miles. The total fall from the junction of the two rivers to just below Smileys falls is about 100 feet. Within 17 miles below Smileys falls, by river, there are at least three different shoals, the last of which is only 8 miles above Fayetteville ; but none of them are of any importance, and they need hardly be considered in this connection.

The outlying gravels of the coastal plain deposits are to be found on the hills two miles to the west of the junction of the Haw and Deep rivers, so that all the shoals just mentioned lie within this region, and the sands and loams and gravels characteristic of the border deposits are exposed here and there in the river bluffs, though in the river channel these have been removed and the waters rush along over the upturned and irregular

eroded edges of granites and crystalline schists. Within a few miles above the junction of the Haw and Deep rivers both of these streams pass from the slates of the Piedmont plateau region to and across a narrow strip of Jura-trias sandstone, which latter is made up of materials far more easily eroded than the slates, and as might be expected there are shoals on both streams at this junction. The rivers join within this sandstone area, and for a few miles below the junction the Cape Fear is a sluggish stream.

ON THE YADKIN–PEE DEE RIVER.

On the Yadkin-Pee Dee river a condition of things exists somewhat similar to that on the Cape Fear just mentioned. The course of the Yadkin river as it crosses the slates, for some 15 miles above its junction with the Uharie, is briefly described further on. Below its junction with the Uharie the river flows for a distance of some 20 miles in a southerly course obliquely across and in places paralleling the upturned edges of the argillaceous slates. In this distance there are only two prominent shoals, but neither of great importance as compared with those at the narrows above. These are Swift Island shoal, 42 to 44½ miles above the state line, and Gunsmith shoal, 13 miles further up the river. Further down, the river flows easterly as a somewhat sluggish stream across a few miles of red sandstone rocks, similar to those crossed by the Cape Fear at the junction of its two tributary streams. It then enters the coastal plain region, near where it is joined by Little river and follows a southerly course via. Cheraw, 35 miles below. Throughout this distance there is a succession of shoals due to the fact that the river crosses the upturned and irregularly eroded edges of alternate beds of slaty and granitic rocks.

The river crosses the lower limit of the fall line zone a little above Cheraw. The shoals in the river at that point and for some distance above are not large, but they are sufficient to mark the passage of the river from its characteristics in the Piedmont plateau region to its typical coastal plain condition, that of a sluggish stream.

GEOLOGIC CONDITIONS FAVORING WATERPOWER DEVELOPMENT AT THE FALL LINE.

(1). The eastward tilting of the surface of these older crystalline rocks, and (2) the partial removal of the loose and easily eroded loams and gravels from the channel on the eastern slope of these rocks, have given this resulting descent in the river surface at the fall line, which, in the Roanoke at Weldon, aggregates 85 feet in 9 miles. (3) The variation in the character of the rock, being harder and more obdurate at certain points, and softer, more jointed, more crushed, and hence more easily eroded at the intervening areas, results in concentrating this fall of the stream at certain places; and (4) the existence of terraces along the river banks facilitates the construction of canals which still further concentrate the fall of the water. These are the more important geologic conditions that favor the development of important waterpowers on the Roanoke at the fall line in the Weldon region.

Other striking cases illustrating the conditions favoring waterpower development on streams crossing geological contacts will be found mentioned on pp. — and — of this report.

WATERPOWER IN THE SLATE BELTS.

One of the most common types of geological structure affecting waterpower development in North Carolina

and other south Atlantic states is that to be found in the great belts of slates and crystalline schists lying in the eastern part of the Piedmont plateau region. (See map). Here, as in structural type shown in fig. 3 below, layers or sheets of rocks are nearly vertical, and are composed of material varying in hardness and durability ; but throughout much of this belt, and especially along its western border, the variations are less well defined and on a smaller scale, the thin, hard layers being so numerous and so generally distributed that in the streams like the Haw and Deep rivers, which cross the larger portions of these belts nearly at a right angle, there is almost a continuous series of small rapids or shoals with an aggregate fall of from 5 to 20 feet to the mile.

The possibility of waterpower development on the Haw, Deep and Yadkin, as they cross the central and most extensive of these slate belts in Alamance, Randolph, Davidson, Stanly and Montgomery counties, is greater than on any other portion of these rivers.

ON THE HAW AND DEEP RIVERS.

Both the Haw and Deep rivers rise in the granitic and gneissic area, the former to the northwest and the latter to the southwest of Greensboro, and are sufficiently large in volume to be available for small powers by the time they reach the western border of the slate belt. Throughout their course of about 50 miles across it each river is a succession of shoals or rapids, many of which have already been developed, while a number of others are capable of being developed on a considerable scale. The slates and schists of this region have a general northeasterly course, and, as a rule, dip steeply toward the northwest, so that these streams with a southeasterly course have cut their beds directly across the upturned

edges of the slates, which vary in hardness and obduracy from point to point, the harder sheets projecting upward as ledges, and the intervening softer sheets being washed out as depressions, which thus give rise to the shoals and rapids.

ON THE YADKIN RIVER.

The Yadkin river strikes the slate belt some 12 or 15 miles below the Southern railroad crossing near Salisbury, and for a distance of 20 miles below this point the geologic conditions in this slate have resulted in a succession of shoals and rapids which promise to be of great value in connection with the development of manufacturing enterprises.

Where the Yadkin river crosses the larger of these belts of slates and schists there is a greater concentration of the hard and soft material, and consequently a greater concentration of fall in the river at certain points, than is described above as occurring on Haw and Deep rivers; yet on the whole this Yadkin river section, illustrated with approximate accuracy in fig. 3, may be considered as fairly typical for sections of country where these belts of rock exist. The space between 1 and 2 in the diagram represents the "narrows" section, a distance of nearly 5 miles. The rock is eruptive in character, though an obscurely bedded conglomerate at the upper (N.W.) side. It is all hard, but not uniformly so, being harder and more obdurate at certain places, arranged at intervals, producing the narrows rapids at the upper end (just below 1) and the "little falls" and "big falls" near the lower end (just above 2). The total fall from 1 to 2 is nearly 100 feet.

Below the narrows (between 2 and S.E. in fig. 3) the



FIG. 3.

FIG. 3.—Conditions favoring the development of cascades and rapids in river channels crossing belts of inclined slates and crystalline schists.

a=Argillaceous slates dipping northwest, with harder and more durable layers at intervals (as at 3). *b*=Crystalline schists, mainly of volcanic origin, obscurely schistose, more massive and obdurate in places, as where the shading is heavier. *c*=Finely laminated and uniform argillaceous slate.

rock is mainly an argillaceous slate of fairly uniform character and easily eroded by water action; and the existence of this softer material beside the belt of hard, obdurate rock which itself is not uniform, but has harder and softer belts, affords just the conditions favorable for the development of rapids and cascades in the stream that crosses both belts. As might be expected, these harder rocks (*b* in fig. 3) cross the country in a high, irregular ridge, while the surface of the region to the southeast, occupied by the slaty and sandstone rocks, is less hilly and less elevated. The Yadkin crosses the harder ridge as a rushing torrent in a deep, narrow gorge—the "Narrows"—but as soon as it reaches the softer slaty rock (at 2 in fig. 3) the current slackens, the stream widens and flows on for several miles as a smooth and relatively sluggish current.

For several miles up-stream from the Narrows the rocks are mainly clay slates having a southwest-northeast course, and dipping steeply toward the northwest;

and so the sheets or beds of rock stand on edge and lean down-stream (S.E.). These rock beds are for the most part fairly soft and more easily washed away than other more massive and more durable layers which occur at irregular intervals, and consequently below these more massive sheets of rock are the shoals and rapids as indicated in figs. 2 and 3 above and as described further on.

WATERPOWER IN THE GRANITIC AND GNEISSIC AREAS.

The larger granitic and gneissic areas occupy the region from the western border of the slate belt just mentioned westward to the foot of the Blue Ridge, the typical Piedmont plateau section of the state.

In granitic and gneissic rock, the materials not being arranged in definite strata or layers, the exact conditions which cause the production of cascades and rapids in streams are less apparent than in the slaty and schistose rocks just described. The accompanying sketch (fig. 4) illustrates a few of the conditions favorable to the development of waterpowers in a region where these rocks prevail, as in portions of central and western North Carolina.

1. One often finds in such regions breaks, such as faults or joints in the rock, the material on one side of the break being somewhat crushed or sheared and hence easily removed. Of course the streams of water in crossing the section of country where these breaks or faults occur, and especially where the crushed or sheared side of the break is the lower side on a sloping surface, remove this lower side more rapidly than the upper and thus form a cascade from the higher to the lower level as seen at 1 in fig. 4. It is in that way that some of the beautiful falls of the southern Appalachian mountain re-

gion have been produced. Other cascades and shoals are developed under the following conditions:

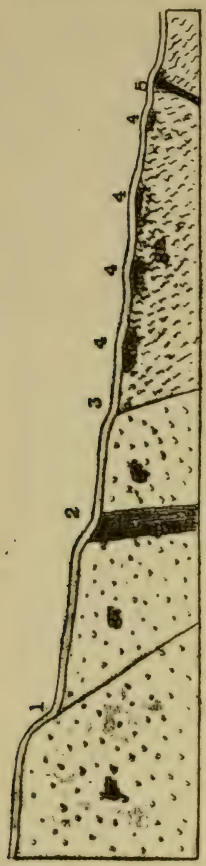


FIG. 4.

FIG. 4.—Conditions favoring the development of cascades and rapids in river channels crossing areas of granitic and gneissic rock.

gr.=Granite. 1=Fault or break in the rock, the right side having moved down or the left side moved up. 2=A schistose zone in the granite resulting from the shearing or movement of the rock along a line of weakness. *gn*=Gneiss, in which there are alternately harder and softer portions, the harder and more obdurate places being more heavily shaded (as at 4). 5=Dike of diabase or other material harder and more obdurate than the gneiss, and never producing a cascade or rapid in the stream channel.

2. In portions of the granitic area there are lines of structural weakness where, under great strain or pressure, the materials of which the rock is composed give way and are flattened out by a process known as shearing, so as to give there a rather gneissic or schistose structure, as at 2 in fig. 4. The rock in this condition is often more rapidly attacked by the weathering and eroding forces of the atmosphere, and, consequently, as the streams cross the surface of the couutry where such conditions exist, they carve out their channels more rapidly, thus producing shoals or rapids, and, in extreme cases, cascades or falls.

3. Conditions somewhat similar to the above and favorable to the formation of shoals and rapids in streams are sometimes found along the line of contact between areas of granites and gneisses, as at 3 in fig. 4; and

again in gneissic areas in places the rocks are harder and more obdurate, as indicated by heavier shading at 4 in fig. 4; and in the beds of streams crossing such areas the rocks wear away irregularly, the harder portions standing out as projections while the intervening softer materials are hollowed out. In this way we have produced a succession of shoals, a few hundred yards or several miles apart; and between these are to be found the quiet reaches of the streams where the current moves along more smoothly and quietly.

4. Another structural feature in granitic and gneissic areas, and also in slaty and sandstone areas, which occasionlly results in the production of the shoals and rapids, is the occurrence of dikes, where cracks in the earth's crust have been subsequently filled with various materials in a plastic and usually a molten condition and which materials have subsequently hardened. If the material of the dike is softer than that of the granitic or gneissic rock on one or both sides of it, then there will be a drop in the course of the stream from the adjoining rock of the wall down on to the softer dike surface, as is shown at 2 in fig. 4. If on the other hand the material constituting the dike is harder and more durable than the materials on each side of it, the country rock on the lower side of the dike, owing to its being softer and less durable than that composing the dike itself, will wear away more rapidly than the material of the dike, and consequently the water will drop from the dike surface on to the country rock below it, as indicated at 5 in fig. 4 above. The occurrence of the belt of eruptive rocks between the two belts of slate, as shown in fig. 3 (p. 103), may be considered as analogous to this last-mentioned case. On the Deep river near Gulf and on New Hope creek, a tributary of Haw river, are to be found illustrations of the development of waterpower being favored by the oc-

currence of diabase dikes in the Jura-trias sandstone crossing the channel of the stream.

ON THE YADKIN AND CATAWBA RIVERS.

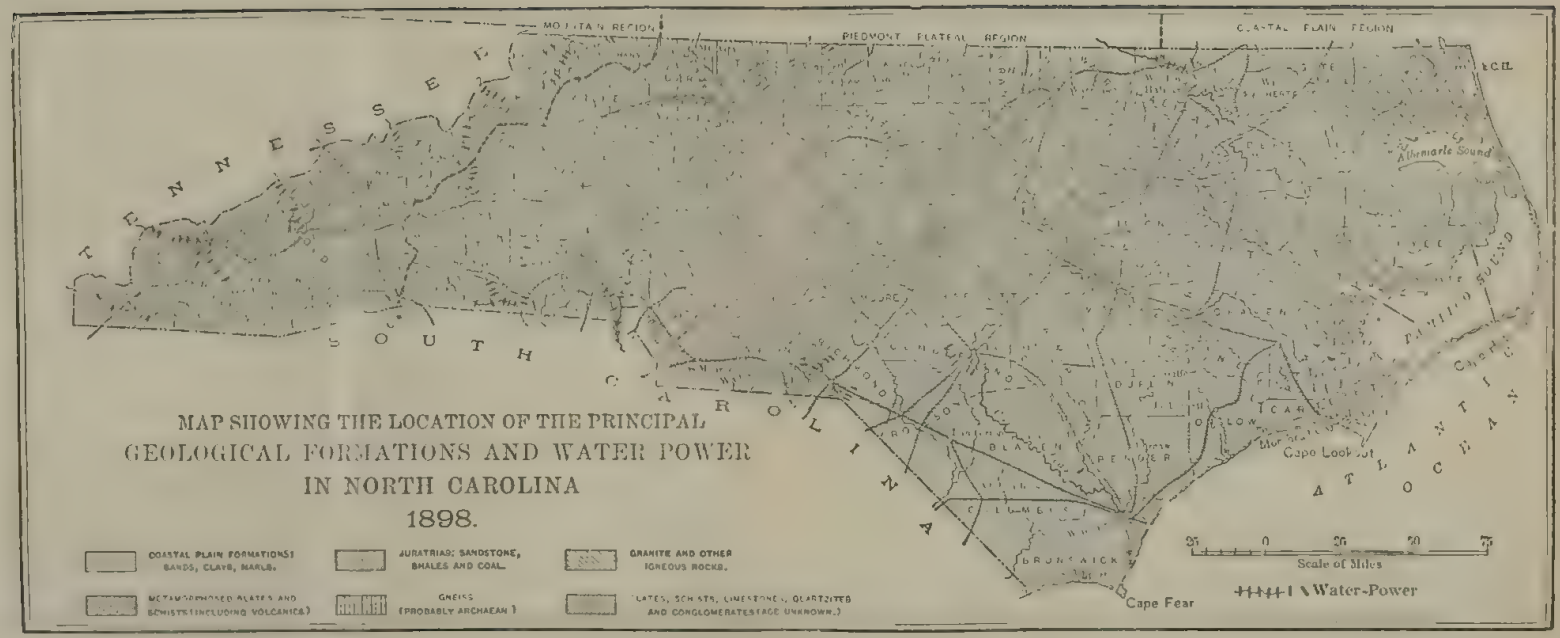
The conditions favoring the development of waterpowers in granitic and gneissic areas have been described very briefly above, and the cascades and shoals and rapids on the Yadkin and Catawba, as well as on the tributaries of the Broad, will generally be found to have their origin in local changes in the character of the rock, in one or another of the ways there suggested. All of the conditions there described are to be found illustrated at intervals in this region.

As will be seen the shoals on the upper Yadkin, which lie within the area now under consideration, are less numerous than those on the same stream in its course across the belt of slate and schist already described. And inasmuch as the changes in the character of the rock in the region of the upper Yadkin are for the most part not radical, the amount of the fall at each of the shoals is less great than in the slate belt. This fact, together with the diminishing volume of water as we ascend the stream, render the powers on the upper portions of this stream less important.

The Catawba river, which, like the Yadkin, rises along the crest and eastern slope of the Blue Ridge, flows nearly a hundred miles in a northeasterly course and then turns southward. Its course in North Carolina lies entirely within the gneissic and granitic area. From Morganton eastward for a distanca of nearly 40 miles the river either parallels the general strike of the rocks or crosses it obliquely. The changes in the character of these rocks are not numerous, and the number of shoals correspondingly small, though several of them are of considerable magnitude. The river then runs in a south-

easterly and southerly direction for a distance of but little more than 25 miles: but in this distance it crosses





MAP SHOWING THE LOCATION OF THE PRINCIPAL
GEOLOGICAL FORMATIONS AND WATER POWER
IN NORTH CAROLINA
1898.

easterly and southerly direction for a distance of but little more than 25 miles; but in this distance it crosses the course or strike of the rocks at right angles. The changes in the character of the rocks are numerous, the rocks even being schistose and slaty in places and the stream is literally a succession of shoals, the aggregate fall being not less than 175 feet. At a point some 10 miles south of Statesville, as will be seen on the small map, the river reaches the typical granite belt of this region and flows thence southward for a distance of approximately 40 miles, where it crosses the state line into South Carolina. In this part of its course the rocks of the region are again more nearly uniform, and though there are several shoals of importance, as those at Cowans ford, Mountain Island, and Tuckaseegee, yet the number of these shoals in proportion to the distance is much smaller than in the 25-mile section next above.

ON THE TRIBUTARIES OF BROAD RIVER.

Among the tributaries of the Broad in Cleveland and Rutherford counties, the streams descend rapidly from the South Mountains along the upper border of these counties down to the general plain of the Piedmont plateau, flowing in a southerly and southeasterly direction nearly at right angles to the general strike of the rock, and in this way encountering the greatest number of changes in the character of these rocks, which results in conditions most favorable for the development of waterpower. Hence it is that we have in this region a large number of valuable waterpowers, some half dozen of which are already operating cotton-mills, while others are soon to be utilized in the same way.

CONDITIONS IN THE SLATY AND GNEISSIC AREAS COMPARED.

In any study of the streams and waterpowers of the

Piedmont plateau region it should be borne in mind that while the slaty belts present more favorable conditions for developing waterpowers, as shown in the case of the Yadkin and the other streams which cross the several belts, owing to the fact that in these belts the sheets of rock stand more on edge and vary more in hardness and durability, yet the streams which draw their supplies from the granitic and gneissic areas are more uniform in their flow for the reason that while the rainfall in the different belts is approximately the same, the soils in the granitic and gneissic areas are deeper and more porous and serve more as a sponge for storing up the surplus water of rainy seasons than does the more shallow and compact clayey soils resulting from the decay of the slates. This is one of the principal causes why the flow is less uniform in the case of the Haw and Deep rivers (see map), which lie largely in the slaty belt, than in the case of the Yadkin and Catawba, which lie almost wholly in the granitic and gneissic areas. Fortunate it is then, that these two larger rivers have their headwaters in the granitic and gneissic areas, with gravelly, porous soils; and flow across the great slate belt after they have attained their larger proportions.

WATERPOWER IN THE MOUNTAIN REGION.

A glance at the accompanying small geologic map will show that the larger part of this region is occupied by gneissic rocks. These have for the most part a characteristic northeast and southwest strike, and the irregular sheets of rock dip beneath the surface at varying but generally steep angles. The southern half of the region has along its western border an irregular belt of bedded slates, limestones, quartzites and conglomerates; and these rocks, which make up the bulk of the Great Smoky mountains, have a general north-

easterly strike and dip at steep and varying angles. Near the eastern border of the region there is another but more narrow and irregular belt of rock of a somewhat similar character, following approximately the general position of the Blue Ridge mountains.

The general physiographic features of the region are those mountains and hills with narrow valleys. It may be restated here that the rivers of this region have their sources mainly along the western slope of the Blue Ridge, and that with the exception of New river, near the northern boundary, they flow in a general northwesterly direction across the upturned edges of both the gneissic and the more recent bedded rocks. The elevation of the country is so great and the descent of the streams so rapid that the general courses of the principal rivers have been but little modified by geologic structure, though their courses lie directly across the strike of the rock; and the resulting conditions are such as to produce along the streams occasional rapids and cascades. Especially would this be the case in the western counties, where the Pigeon, the Tuckasegee, the Little Tennessee and the Hiwassee break through the Great Smoky mountains, and in doing so cross a variety of limestone, quartzite and conglomerate beds which go to make up the geologic formation of that area, but for the fact that during the long period of time that these streams have occupied their present channels, owing to the rapidity of their flow and the large quantities of abrading materials, such as sand, gravel and bowlders, carried down in their currents, the variations in the obduracy of the rocks, crossing these stream beds seldom result in cascades of large proportions, for the reason that the would-be projecting ledges of rock across the stream bed are kept down near the general level by these eroding agencies.

A number of the smaller tributary streams flow in either

a southwesterly or a northeasterly direction along the line of the strike of the rocks and thus develop the conditions favorable for waterpower, mainly where they vary their courses and cross from rock of one character to one of a different character. In the extreme northern portion of the region the tributaries of New river rise both on the western slopes of the Blue Ridge and the eastern slopes of the Iron mountains, and flow in a general northeasterly or northerly direction, sometimes following the line of the strike, and sometimes crossing the latter at sharp angles. Along New river and its tributaries are a number of shoals which can be developed into valuable waterpowers, occuring mainly at points where the streams cross the strike of the gneissic rock of the region.

In connection with the development of these waterpowers, the river gorges are so narrow and the streams so rapid that while the construction of large dams is a matter attended with no insurmountable difficulties, yet it is often difficult to find suitable space for buildings, and it has been found more advisable in a number of cases to construct small dams and to convey the water from these in open ditches or flumes along the banks of the stream to suitable points where the power may be utilized. The chief difficulty which is met in storing water on these streams is that the ponds or storage reservoirs become rapidly filled with sand, gravel and bowlders brought down in time of flood. Probably the future development of these powers will be largely in connection with electrical transmission.

GEOLOGICAL CONDITIONS AFFECTING THE FLOW OF STREAMS.

The yearly discharge of a stream depends primarily on the amount of rainfall in the region from which the stream draws its supply, but in a measure this volume, and especially the uniformity of flow, are largely in-

fluenced by the slope of the surface, the depth and porosity of the soil, and the character of the underlying rock. In connection with this study of the geologic conditions influencing the possibilities of waterpower development, it should be noted that the occurrence of lakes, swamps or marshes and poorly-drained level areas, deep and porous soils, such as the sandy and gravelly soils from 10 to 100 feet deep, which occur in the larger part of the Piedmont plateau and mountain regions of the Carolinas, the great sand hills of the southern coastal plain region, and the porous sands and gravels of the glaciated regions of the Northern states, all facilitate the uniformity of the flow of the streams in these several regions; and in some regions the jointed, fissured and crushed condition of the underlying rock exerts a favorable influence in the same direction.

NOTES ON GRASSES.

1) CONTRIBUTIONS FROM MY HERBARIUM. NO. IV.

W. W. ASHE.

Since the publication of a paper on the Dichotomous Group of Panicum in the Eastern United States (in this Journal, vol. xv, Nov., 1898) I have found among some duplicates additional material of a plant, a single specimen of which I had at that time, but such scanty material that I did not care to base a species on it, though it

1) Issued April 20, 1899.

showed excellent specific characters. I find that I have collected the plant at two stations, both in Orange county, N. C.

PANICUM ORANGENSIS, sp. nov. Stems 12 to 24 inches long, ascending from a geniculate base, pubescent with long, soft, white, matted hairs, but more or less glabrate towards the top. Lower sheaths crowded and overlapping, pubescent with soft matted hairs; the upper distant and nearly glabrous. Leaves soft-pubescent like the sheaths, the largest 3 to 4 inches long and 3" to 5" wide, lanceolate, long taper-pointed, largest near the base of the stem; the upper much reduced and often glabrous. Ligule pilose with long hairs. Panicle long-peduncled, oblong, the very numerous, slender fascicled branches ascending; spikelets scarcely $\frac{3}{4}$" long, obovate, apiculate, the first scale about one-third as long as the glabrous 7-nerved second and third.

Related to *Panicum lanuginosum* Ell., and separated from it by having a longer, softer pubescence and its leaves not being ciliate. Collected in June, 1898.

As the name *Panicum commelinaefolium* proposed by me (Mitchell Journ. 15, part 1; 29) for a Georgia plant has already been used by Kunth for another grass, I propose the name *Panicum Currani* for my plant; and for *Panicum Georgianum* Ashe (ibid, 36) I propose the name *Panicum Cahoonianum*, since Sprengel has made use of the nearly similar *P. Georgicum* for a different plant.

ANDROPOGON GYRANS sp. nov. Stem very slender, 18 to 24 inches high, glabrous or merely bearded at the upper joints. Basal leaves 10 to 14 inches long, 1" wide or less, glabrous, often involute and twisted, those of the stem much shorter. Sheaths glabrous. Branches very few, scarcely protruding from the closely wrapped sheaths. Spikes 2 or 4, generally 4, very slender, 6 to 12 flowered, spikelets $1\frac{1}{2}$" long, shorter than the copious, white, basal hairs; sterile spikelets of single scale, cov-

ered with long spreading hairs, as well as its slender pedicel.

Distinguished from A. *Elliotii* and all the slender forms of that species, by the much smaller spikelets, scattered branches and narrow sheaths, which do not enlarge.

Collected by the writer in pine woods in Durham county, N. C., Oct. 1896.

ANDROPOGON MOHRII PUNGENSIS, var. nov. Less tomentose than the type. Spikes generally more numerous, 4 to 12, and shorter, enclosed in the sheaths or protruding.

Collected by the writer in grassy swamps at the head of Pungo river, Washington county, N. C., Oct. and Nov., 1898.

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SIXTEENTH YEAR—PART FIRST

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THE DEFINITION OF THE ELEMENT.

F. P. Venable.

It is with hesitation that I enter upon so speculative a discussion as the nature of the elements, and yet there are reasons why it should prove of great profit to draw the attention of this representative gathering of the chemists of America to this subject. We have nearly reached the close of the first century in which these elements have been the subject of experimental research. The ingenuity and the patient labor of an army of workers have been directed toward the solution of the many problems connected with these elementary substances, and the ultimate aim, the goal, of all their striving has been the discovery of the properties and the nature of the atom.

It is eminently fitting that, as we stand at the threshold of the new century, we glance back along the road we have already come and take some account of the progress we have made. The quicksands of mere speculation must be avoided, and yet the mental vision, the 'scientific imagination,' must be called into service in considering that which so far transcends our cruder actual vision as the incomparable atom itself. There is another reason for considering the nature of

* An address delivered as Vice President before the Chemical Section American Association for the Advancement of Science—Columbus, O., 1899.

the elements. At several times during the century a wider vision has made it necessary to recast the definition of the elements to accord with increasing knowledge. It would seem as if another such period of change were approaching. There may be need of a truer definition, and how shall this be realized or the new definition properly fitted unless the knowledge gained be summed up and appreciated?

The conception of an element among the Greek philosophers and the earlier alchemists was very different from the modern idea. This conception sprang from the theories as to the formation of the material universe. The elements were the primal forms of matter seen only combined, impure, imperfect. They were the essences or principles out of which all things were evolved. In the four-element theory, which was so widely spread among the ancients, the fire, air, earth and water were not the ordinary substances known under these names, but the pure essences bestowing upon fire and water their peculiar properties. These essences were not thought of as actual substances capable of a separate material existence, and gradually the belief that a transmutation was possible between them sprang up. Thus they themselves might be derived from some one of them, as fire or water. The Thalesian theory deriving all things from water was especially popular and was not completely overthrown until the modern era.

When, later on, the alchemists conceived of all metals as composed of sulphur and mercury it was an essence or spirit of mercury that was meant. Certain common characteristics as luster, malleability, fusibility, combustibility, etc.,naturally led them to think of the metals as belonging to the same order of substances containing the same principles, the relative proportions and purity of which determined the variations in the observed properties. Thus the properties of the metals depended upon the purity of the mercury and sulphur in them, the quantities of them and their degree of fixation. The more easily a metal was oxidized on being heated, the more sulphur it contained, and this sulphur also determined its changeability. The more malleable it

was, the more mercury entered into its composition. If only something could be found which would remove the grossness from these essences, some unchanging, all-powerful essence, which, because of their search for it, gradually became known as the 'philosophers' stone,' then the baser metals might be transmuted into the noble gold when the sulphur and mercury were perfectly balanced and free from all distempers.

As has been said, these principles entering, all or some of them, into every known substance, were supposed to be not necessarily capable of individual existence themselves. This was the view held by the followers of Aristotle. With the reaction against the domination of the scholiasts, other views began to be held. It was Boyle who first gave voice to these changed views in his 'Sceptical Chymist' (1661). He defined elements as "certain primitive bodies, which, not being made of any other bodies, or of one another, are the in gredients of which all those called perfectly mixed bodies are immediately compounded, and into which they are ultimately resolved." He, however, did not believe himself warranted, from the knowledge then possessed, in claiming the positive existence of such elements.

But little attention was paid to the subject by the subsequent chemists. The phlogistics were too much occupied with their theory of combustion, and none could see the bearing of this question and its importance to exact science.

Macquer, in his 'Dictionary of Chemistry' (1777), words his definition as follows: "Those bodies are called elements which are so simple that they cannot by any known means be decomposed or even altered and which also enter as principles or constituent parts, into the combination of other bodies." To this he adds: "The bodies in which this simplicity has been observed are fire, air and purest earth." In all of this may be observed the resolution of observed forms of matter into primal principles following the dream of Lucretius and the early Epicurean philosophers, a dream abandoned by the atomic school following, though largely holding to the same definition.

It was only when chemists began to realize that mere observation of properties, chiefly physical, was not sufficient that the subject began to clear up and lose its vagueness. Black proved that certain substances were possessed of a constant and definite composition and fixed properties, unalterable and hence simple bodies or elements. Lavoisier finally cleared the way for the work of the nineteenth century by his definition that "an element is a substance from which no simpler body has yet been obtained; a body in which no change causes a diminution of weight. Every substance is to be regarded as an element until it is proved to be otherwise." With this clear definition to build upon, a rational system of chemistry became, for the first time, a possibility.

Thus the elements were recognized as simple bodies because there were no simpler. They were not complex or compound. This distinction was clearly drawn between bodies simple and bodies compound, and the name simple body has been frequently used as a synonym for element through a large part of this century. Naturally the question of simplicity was first settled by an appeal to that great arbiter of chemical questions, the balance. And, quite as naturally, many blunders were made and the list of bodies erroneously supposed to be simple was very large. All whose weight could not be reduced were considered elementary. When, however, from such a body, something of lesser weight could be produced, its supposed simplicity was, of course, disproved.

This test for the elemental character has been clung to persistently, and is perhaps still taught, although it was long ago recognized that many of the elements existed in different forms, a phenomenon to which Berzelius gave the name *allotropism*. One only of these could be the simplest, and the others could be reduced to this one and rendered specifically lighter. With the discovery of this relation it should have been quite apparent that the old definition would no longer hold good. But many years passed before chemists were made to feel that a new definition was necessary, and adapted one to the newer knowledge.

The insight into what Lucretius would call 'the nature of things' was becoming clearer; the mental grasp upon these elusive atoms about which the old Epicurean reasoned so shrewdly was becoming firmer. Through what one must regard as the veil interposed by the earlier idea of the element, the chemist began to grope after the constituent particle or atom. It must be borne in mind that the definition of the element was largely formulated before the resuscitation of the atomic theory by Dalton, and the mental picture of the one has perhaps retarded the clearing up of the ideas concerning the other. From the atomic point of view the element was next defined as one in which the molecules or divisible particles were made up of similar indivisible particles. This afforded an easy explanation of allotropism as a change in the number of atoms in a molecule. As Remsen says: "An element is a substance made up of atoms of the same kind; a compound is a substance made up of atoms of unlike kind."

Laying aside, then, all vaguely formulated ideas of essences, or principles, or simple bodies, or elemental forms, we found our present building upon the conception of the ultimate particle, be this molecule or atom.

As to this atom some clear conception is needed, and here we come to the *crux* of the modern theories. The chemist regards this atom as a particle of matter and is unwilling to accept the theory of Boscovich that is infinitely small, and hence a mathematical point, nor can he admit that it is merely a resisting point, and hence that all matter is but a system of forces. And yet it seems as though some authorities would lead up to such a conclusion.

While we need not consider these atoms as mere centers of forces, we are compelled to study them by the operation of forces upon them. What are called their properties have been studied and recorded with great care. These properties are evinced in the action of the forces upon matter, and the exhibition of force without matter cannot be admitted. This study of the properties has been the especial occupation of the century now closing, and so the elemental atom has come to be regarded as a collection of properties. As Patterson-Muir puts it (Alchemical Essence and the Chemical

Elements, p. 31): "The name copper is used to distinguish a certain group of properties, that we always find associated together, from other groups of associated properties, and if we do not find the group of properties connoted by the term copper we do not find copper."

These properties are exhibited by the action of a small group of forces. Perhaps we do not know all of the forces; certain it is that we do not accurately know all of the properties, but, to quote Patterson-Muir again: "The discovery of new properties always associated with a group of properties we call copper would not invalidate the statement that copper is always copper."

The properties of an atom are either primary, inherent and as unchanging as the atom itself, or they are secondary and dependent upon the influence of the other atoms, or varying with the change of conditions. To the first class belong such properties as the atomic weight, atomic heat, specific gravity, etc.; to the second, chemical affinity, valence, etc. In all the study of the atom the distinction between these should be carefully maintained in order that there may be clear thinking.

There is no field of mental activity requiring more faith than that of the chemist. He is dealing with the 'evidences of things unseen.' He must not be content with the mere gathering of facts, but divine what he can of their deeper meaning. Few chemists have had such insight as Graham into the significance of even the simplest changes. He was not content with mere surface observation. Even the commonest phenomena were to him full of meaning as to the atoms and their 'eternal motion.' Thorpe (Essays in Historical Chemistry, p. 219) has drawn afresh the attention of the chemists to the thoughtful words of this great thinker. His mind was filled with the fascinating dream of the unity of matter. "In all his work," says Adam Smith, "we find him steadily thinking on the ultimate composition of bodies. He searches after it in following the molecules of gases when diffusing; these he watches as they flow into a vacuum or into other gases, and observes carefully as they pass through

tubes, noting the effect of weight, of composition, upon them in transpiration. He follows them as they enter into liquids and pass out, and as they are absorbed or dissolved by colloid bodies; he attentively inquires if they are absorbed by metals in a similar manner, and finds remotest analogies which, by their boldness, compel one to stop reading and to think if they really be possible."

In his paper entitled 'Speculative Ideas respecting the Constitution of Matter,' published in the Proceedings of the Royal Society in 1863, which Thorpe calls his 'Confession of Faith,'he tells of his conception that these supposed elements of ours may possess one and the same ultimate or atomic molecule existing in different conditions of movement.

It is not possible for me, in the limits of this address, to array before you all of the various evidence which leads to the belief that our so-called elementary atoms are after all but compounds of an intimate, peculiar nature whose dissociation we have as yet been unable to accomplish. When properly marshalled, it gives a very staggering blow to the old faith. Thorpe speaks of the "old metaphysical quibble concerning the divisibility or indivisibility of the atom." To Graham "the atom meant something which is not divided, not something which cannot be divided." The original indivisible atom may be something far down in the make-up of the molecule.

How shall the question as to the composite nature of the elements be approached? The problem has been attacked from the experimental side several times during the last half century, but the work seems to have been carried on after a desultory fashion and was soon dropped, as if the workers were convinced of its uselessness. The results, being negative, simply serve to show that no method was hit upon for decomposing the elements upon which the experiments were performed. Thus, for instance,Despretz performed a number of experiments to combat Dumas' views as to the composite nature of the elements. Despretz made use of the well-known laboratory methods for the separation and purification of substances. Such were distillation, electrolysis, fractional

precipitation, etc. Such work was quite inadequate to settle the question, as Dumas had pointed out that unusual methods must be used, or, he might have added, the old methods carried out to an unusual or exhaustive extent. Certainly, if a moderate application of the usual methods was sufficient for this decomposition, evidences of it would have been obtained long ago by the host of careful workers who have occupied themselves over these substances. Crookes has busied himself with the method of fractional precipitation (though not with special view to the testing of this question), and applied it most patiently and exhaustively to such substances as the rare earths, without obtaining results from which anything conclusive could be drawn. Victor Meyer seems to have believed that the decomposition could be effected by high temperatures, and was very hopeful of experiments which he had planned before his untimely death. Others have spasmodically given a little time to the problem, but no one has thought highly enough of it to attack it with all of his energy.

Let us stop a moment and ask ourselves what would be attained if any one should succeed in decomposing an element by one of the usual methods. Has not this been done repeatedly in the past and merely served to add to the list of the elements? Didymium has been made to yield praseo-and neodymium. That which was first called yttrium has been divided into erbium, terbium and ytterbium, and according to Crookes may possibly be still further decomposed. But these and similar decompositions are not generally accepted as offering any evidence that elements can be decomposed. It is merely the discovery of one or more new substances which have remained hidden in constant association with known bodies which were supposed to be simple. It would be necessary to prove that a single individual element had, by the process adopted, been actually decomposed and not some preexisting impurity discovered. This, of course, would be exceedingly difficult, and all such attempts as those mentioned can have little bearing upon the general question, and can hold out slight hope of reward beyond the fame springing from the discovery of a new element.

Successful decomposition should meam much more. It should mean the discovery of a method which will decompose not one, but many or indeed, all of the elements, and the de composition of these must not yield a larger number of supposedly simple bodies, but a small group of one or two or three which are common constituents of all. It is quite idle to venture upon any prediction whether such a method will ever be discovered. Setting aside, then, the direct experimental proof of the composite nature of the elements as unattainable at present, let us next examine the indirect evidence. It would seem wisest for the present to introduce under that heading the spectroscopic work of Lockyer. The results, while highly interesting, are too indefinite as yet to speak of as having a direct bearing. Yet a careful study of the spectra of the elements leads us to a strong suspicion that the less plausible assumption is the one that the particles which give rise to such varied vibrations are simple and unitary in nature. Lockyer's most recent work, following up the line of his 'Working Hypothesis' of twenty years ago,is very suggestive and may lead to important results (Chemistry of the Hottest Stars, Roy. Soc. Proc., LXI., 148; On the Order of Appearance of Chemical Substances at Different Temperatures, *Chem. News*, 79, 145). Still too much must be assumed yet for such work to be very conclusive. He writes of 'proto-magnesium and proto-calcium,' and Pickering discusses a 'new hydrogen,' all with an assurance and confidence which proves at least how deeply these changes in the spectra have impressed some of those who have most carefully studied them.

But a more important method of indirectly testing the question is through a comparison of the properties of the atoms. Such a comparison has been made as to the atomic weights. In other words, the idea of the composite nature of the elements followed very close upon the adoption of a stricter definition of them as simple bodies. Dalton, Prout, Döbereiner, Dumas, Cooke and many others have aided in developing the idea, sometimes faultily and harmfully, at other times helpfully. Some fell into the common error of going too far, but all were struck by the fact that

when these combining numbers, or atomic weights, were compared strange and interesting symmetries appeared. The times were not ripe for an explanation of their meaning, and such crude assumptions as that of Prout, that the elements were composed of hydrogen, or that of Low, that they were made up of carbon and hydrogen, were too baseless to command much genuine support or to withstand much careful analysis. The important feature of agreement between such theories was the belief that the elements were composite and had one or more common constituents.

From the comparison of one property, the atomic weights, the next step was to the comparison of all the properties. This comparison is brought out clearest and best for us in the Periodic System. Here all the properties are very carefully tabulated for us. The study of the system leads indisputably to the conviction that this is not an arbitrary, but a natural arrangement, exceedingly simple in its groundwork, but embodying most fascinating symmetries, which hint of great underlying laws. He who looks upon it as a mere table of atomic weights has lost its meaning. It tells, with no uncertain note, of the kinship of the elements and leads to a search after the secret of their interdependence and of their common factor or factors. There is so much which is made clearer if we assume a composite nature for the elements that many do not hesitate to make the assumption.

Still another indirect method of approaching that problem is by analogy with bodies whose nature and composition are known. A very striking symmetry is observed between the hydrocarbons, and these in the form of compound radicals show a strong resemblance to certain of the elements. This analogy need not be dwelt upon here. It has been recognized for a long time and tables of hydrocarbons have been constructed after the manner of the Periodic System. Now these bodies are simply built up of carbon and hydrogen in varying proportions, and in any one homologous series the increments are regular. We know that they are composite and that they have but two common factors, carbon and hydrogen.

Again, the fact that certain groups of associated atoms behave as one element and closely resemble known elements may be taken as a clue to the nature of the elements. Thus carbon and nitrogen, in the form of cyanogen, behave very much like the halogens; and nitrogen and hydrogen in the form of ammonia so closely resemble the group of elements known as the alkalies that this "volatile alkali" was classed with them before the era of our elements and the analogy lead to a vain search for an "alkalizing principle" and later to an equally futile pursuit of the metal ammonium.

A further clue to this nature is afforded in the remarkable changes of properties which can be brought about in some elements by ordinary means, and one might mention the equally remarkable veiling of properties induced by the combining of two or more atoms. Thus copper exists in a cuprous and a cupric condition, and the change from one to the other can be readily brought about. And this is true of many other elements.

This has doubtless been a tedious enumeration to you of well-known facts and arguments, but it has been necessary, for I wish to lead you to the summing-up of these arguments and to induce you to draw boldly the necessary deductions. It is high time for chemists to formulate their opinions in this matter. It would seem as if we were shut up to one or two conclusions. Either these imagined simple bodies are after all compounds, built up of two or more common constituents, or they are but varying forms of one and the same kind of matter subjected to different influences and conditions. The supposition that they are distinct and unrelated simple bodies is, of course, a third alternative, but to my mind this is no longer tenable.

The second hypothesis is the one put forth by Graham. It was his cherished vision of the gaseous particles about which he thought so deeply, and in many ways so truly. Thorpe has written of this as follows (loc. cit. 222):

"He conceives that the various kinds of matter, now recognized as different elementary substances, may possess one and the same ultimate or atomic molecule existing in different conditions of movement. Graham traces the harmony

this hypothesis of the essential unity of matter with the equal action of gravity upon all bodies. He recognizes that the numerous and varying properties of the solid and liquid, no less than the few grand and simple features of the gas, may all be dependent upon atomic and molecular mobility. Let us imagine, he says, one kind of substance only to exist —ponderable matter; and, further, that matter is divisible into ultimate atoms, uniform in size and weight. We shall have one substance and a common atom. With the atom at rest the uniformity of matter would be perfect. But the atom possesses always more or less motion, due, it must be assumed, to a primordial impulse. This motion gives rise to volume. The more rapid the movement, the greater the space occupied by the atom, somewhat as the orbit of a planet widens with the degree of projectile velocity. Matter is thus made to differ only in being lighter or denser matter. The specific motion of an atom being inalienable, light matter is no longer convertible into heavy matter. In short, matter of different density forms different substances—different inconvertible elements, as they have been considered."

The hypothesis that the elements are built up of two or more common constituents has a larger number of supporters and would seem more plausible. Some have supposed one such primal element by the condensation or polymerization of which the others were formed. Thus we have the hydrogen theory of Prout, modified to the one-half atom by Dumas, and finally by Zängerle to the one-thousandth hydrogen atom. The suggestion of Crookes as to the genesis of the elements from the hypothetical *protyle*, under the influence of electricity, may also be mentioned here.

Others have adopted the supposition of two elements, Reynolds making one of these an element with a negative atomic weight, whatever that may mean. Low and others have fixed upon carbon and hydrogen as the two elements.

There are many practical difficulties in the way of these suppositions; the lack of uniformity in the differences between the atomic weights, the sudden change of electro-chemical character, and the impossibility, so far, of discovering

any law underlying the gradation in the properties of the elements with the increase of atomic weights, are some of the difficulties. In comparing these two hypotheses that of Graham seems to me very improbable. I have thought of valence as dependent upon the character of the motion of the atom, but cannot well conceive of a similar dependence of atomic weight and all the other properties. There remains, then, the hypotheses of primal elements by the combination of which our elements have been formed. These molecules are probably distinguished from the ordinary molecules by the actual contact and absolute union of the component atoms without the intervention of ether.

Since these elemental molecules cannot as yet be divided, we may retain the name atom for them, but the idea of simplicity and homogeneity no longer belongs to them. The definition of an element as a body made up of similar atoms is equally lacking in fidelity to latest thought and belief, but chemists would scarcely consent to change it, and, indeed, it may well be retained provided the modified meaning is given to the word atom. But, after all, an element is best defined by means of its properties. It is by close study of these that we decide upon its elemental nature, and through them it is tested. Complete reliance can no longer be placed upon the balance and the supposed atomic weight.

All elements are acted upon by gravity and chemical force and other physical forces, but within the last few years certain gaseous elements have been discovered which are not influenced by chemical force or affinity. According to some (Piccini, *Zeits. An. Chem.* XIX, 295) this necessitates a division of the elements into two classes. Manifestly, since it is chiefly by the action of chemical force that we study the elements, the absence of such action cuts us off from our chief means of finding out anything about them, and it is equally clear that bodies so diverse cannot well be classified together. If all attempts at bringing about the chemical union of these gaseous elements with other bodies fail, I believe that we should insist upon the existence of two classes of elements and keep them distinct in all comparisons.

Of course, we are quite at a loss to say just what chemical force is, but it is believed to be determined by the electrical condition of the atom. Thus we have the elements which show the action of chemical affinity varying from strongly electro-positive to strongly negative. This electrical charge of the atom seems to be a primitive, inherent property, and so beyond our control or power to change. At least no change of the kind has ever been recognized and recorded. Sodium remains positive and chlorine negative in spite of all that may be done to them. We can, by uniting the two temporarily, cloak and neutralize their opposite natures, but the original condition returns on their release.

Is it not fair to assume that argon, helium and their companion gases, having no affinity, are without electrical charge —atoms from which the electrical charge has been withdrawn; the deadest forms of inanimate matter? Were they thus without electro-chemical properties and affinity from the beginning, or did they start out as ordinary atoms (if I may so call them), and somehow, somewhere lose these properties, and with them the power of entering into union of any kind, even of forming molecules, doomed to unending single existence? Can these be changed atoms of some of our well-known elements, a step nearer to the primal elements and with the electrical charge lost? Is it possible for us to bring about these changes? May we not unwittingly have done so at some time or other in the past? Is it possible to restore the electrical charge to such atoms, and so to place them once more on a footing of equality with elements of the conventional type? These and many other questions surge through the mind as one thinks of these wonderful gases. Perhaps the coming century will unfold the answers.

THE NATURE OF VALENCE.

By F. P. Venable.[1]

The term "valence" is variously defined as the "combining capacity," or "capacity of saturation," "quantitative combining power," or "chemical value of the atom." It is well known that the introduction of this idea into chemistry was due to the development of the type theory, a system which had at first purely empirical basis. Sixty years ago there was still some hesitation as to the acceptance of the atomic theory or the need for such a theory. Much use was made of the term equivalent, which had been Wollaston's expedient for avoiding the difficulties arising from the full adoption of the theory of atoms.

Wollaston had been himself very far from consistent in the use of the term. The numbers called by him 'equivalent weights' were not infrequently atomic and molecular weights and fully as hypothetical as the so-called atomic weights of Dalton. In the later use of the term it signified solely the numbers obtained by analysis without the introduction of any theoretical considerations. Thus, on analyzing ammonia, the ratio

$$N : H :: 4.6 : 1,$$

is gotten, and therefore the equivalent of nitrogen is 4.6. Strange to say the equivalent given by Wollaston corresponds with the present atomic weight, whereas the atomic weight given by Dalton corresponds with what would be the equivalent.

It is manifest that the idea of equivalents needed something more than the simple theory of atoms to make it clear and tenable. It embodied two distinct conceptions and if we hold to an atomic theory we must introduce a further explanatory theory of the saturation capicity of these atoms. This

[1] Address, as chairman, delivered before the North Carolina Section.

is the theory of valence or quantivalence or atomicity, and without it the equivalents are purely empirical, and it is most difficult if not impossible to clear up the confusion connected with their use.

Returning now to the derivation of this idea of valence from the type theory, according to Wurtz[1] the conception of valence was introduced into the science in three steps. First there was the discovery of polyatomic compounds. This term was first used by Berzelius in 1827[2], he applying it to such elements as chlorine or fluorine where he thought several atoms of these elements united with a single atom of another element. The term was later applied by Graham, Williamson, and others to compounds.

The second step was the reference of this polyatomicity to what was called the state of saturation of the radicals contained in these compounds. This was largely through the work of Williamson and Gerhardt.

Thirdly, this conception of saturation was extended to the elements themselves. This was chiefly due to the work of Frankland upon the organo-metallic compounds. And so valence has come to refer to the number of atoms with which a single atom of any element will combine.

This conception has then been one of slow growth, gradually incorporating itself into the science as the necessity arose of devising a suitable explanation for accumulated observations. It was a logical outcome of and was evolved from knowledge acquired step by step. It was no mere speculation or hypothesis, such as that of Prout, evolved by the fancy or imagination of one man and suddenly appearing with scarcely a claim to foundation upon observed fact.

This conception enters into the chemical theory of to-day almost as fundamentally as the atomic theory itself. Its application is of every-day occurrence and of the most varied character, and yet chemists admit that the nature of valence is one of their chief puzzles and they have advanced but little towards its solution during the past half century. It is quite

1 Historie des doctrines chimiques, p. 69.

2 *Jsb. d. Chem.*, 7, 89.

possible that the ideas to be advanced in the further discussion of this subject in this paper will meet with opposition. Certainly they should be fully and freely discussed if they are worthy of it. I believe that they form a step toward the clearing up of the mystery of valence.

It is necessary, however, first to trace somewhat further the development of the original conception. One of its earliest and most important applications was to the study of the constitution of the compounds of carbon. Here Kekulé assumed for carbon a constant valence of four, and this idea is still dominant in theories relating to the constitution of these bodies. It was quite natural then that the first belief should have been in a constant valence. It was speedily found, however, that in certain cases, as in the compounds of nitrogen and phosphorus, this belief was scarcely tenable. There were efforts at making it hold good, as, for instance, a distinction was drawn between atomic and molecular compounds, but all of these suggestions have been proved unsatisfactory.

We unquestionably have to account for the existence of a compound with three atoms and another with five atoms in the cases of nitrogen and phosphorus and there are many similar anomalies. Here the valence seems to vary toward one and the same element. Cases might be multiplied to show also that it varies often towards different elements. Thus it frequently happens that the valence of an element towards hydrogen seems to be quite different from that exhibited toward oxygen. For a long time there was much straining to consider the valence of an element always the same but this effort is, in large measure, abandoned now as unavailing and chemists admit that valence is not constant but variable and may even vary towards one and the same element.

The doctrine of valence has had much added to it about bonds, affinities, and linkage, the necessity for which one may well question. Certainly the misuse of the word affinity, seeing its other and greater use, should be earnestly discountenanced. I am inclined to think that the other terms bring in false and misleading ideas which should be carefully guarded

against. At any rate all hypothetical talk about strong bonds, and weak bonds, double bonds and triple is to be avoided.

If then valence varies, can it be an inherent property of the unchanging atoms? Experiments have shown that it varies with the nature of the combining element, that it varies with the temperature and with other conditions. It is not dependent upon the atomic weight in the same sense as other properties are dependent upon it. Thus in the same group the valence remains the same whether the atoms weigh nine times as much as hydrogen or two hundred times as much.

We seem shut up to the conclusion that valence is not one of the primitive inherent properties of the atom but is relative. It is rather to be regarded as the resultant of the mutual influence of the atoms of the combining elements. The clear grasping of this idea is an importhant step forward. Unfortunately the distinction is not always made nor consistently adhered to.

It may not be amiss to cite here the utterance of Lothar Meyer in regard to the question of a constant or variable valence:[1]

"Since the aim of all scientific investigation is to exhibit the most variable phenomena as dependent upon certain active invariable factors taking part in them and in such a manner that each phenomenon appears to be the necessary result of the properties and reciprocal action of these factors, then it is clear that chemical investigation would be considerably advanced were it possible to prove that the composition of chemical compounds is essentially determined by the valency of the atoms and the external conditions under which these atoms react upon one another. The first necessary step in this direction has been made in the attempt to explain the regularities observed in the composition of chemical compounds, by the assumption of a constant power of saturation or an invariable valency of the atom. The opposite and equally hypothetical assumption that the valency is variable leads to no advancement.

"The first step towards progress in this matter would be

[1] Modern Theories of Chemistry, Eng. Trans., p. 303.

made if some hypothesis as to the cause of this variability were proposed. This difference between the two attitudes has seldom been properly realized. While some chemists, accepting the constant valency of atoms, have attempted to deduce the varying atomic linking from one distinct point of view, others have considered it sufficient to have assigned to the atom of a particular element in one compound one valency, and in another compound a different valency, according as this or that value appeared the most suitable, and thus to have given a so-called explanation of the composition of the compounds in question. In this way the fact has been overlooked, that an arbitrary interpretation carried out by means of chosen hypotheses, cannot be regarded as an attempt at a scientific explanation, but is nothing more than an expression of our ignorance of the causal connection of the phenomena. An explanation would require that the different valencies assigned to one and the same element in different compounds, should be traced to a different cause. If, for instance, it is stated that carbon in carbon dioxide possesses double the valency which it possesses in carbon monoxide, such a statement is no explanation of the fact that an atom of carbon in the former compound is combined with twice as much oxygen as in the latter, for such a statement is merely a paraphrase which hides its incompetency by assuming the form of an explanation. Although this may be perceived without further remark, still it has frequently occurred during the past few years that similar paraphrases have not only been proposed but also accepted as real explanations of such phenomena. Just as it was formerly supposed that the assumption of a vital force dispensed with a complete investigation of the phenomena of animal life, so many chemists have of late thought that they possessed in 'variable valency,' a means of explaining the varying stoichiometric relationships which would satisfy all claims. Such deceptions can only retard the advance of the science, since they prevent an earnest and thorough investigation of the question, whether each atom is endowed with a property determining and limiting the number of atoms with which it can combine, dependent upon the intrinsic na-

ture of the atom and like it invariable ; or whether this ability is variable and with it the nature of the atom itself."

It is not strange that this line of reasoning should lead Lothar Meyer to doubt the unvarying nature of the atom itself, and thus losing his grasp upon one invariable to make sure of another. He says: "It is by no means impossible that the magnitudes which we now style atoms, may be variable in their nature."

It will be an unfortunate day for chemists when the belief in the unchanging atom is given up. Chaos will indeed enter into all of our theories when this, the foundation rock, is left at the mercy of every shifting tide of opinion and can be shaken by all manner of unfounded hypotheses.

The case cannot be so hopeless as to necessitate calling to our aid so dangerous a doctrine. Before turning to such an expedient let us first make all possible use of our atomic theory as it stands. The extension of this theory teaches that the atoms are endowed with motion and this motion probably varies in velocity and phases with the different elements. So too when the atoms unite the resulting molecule has a certain motion peculiar to it while the atoms composing it have an intra-molecular motion in which their original motions are probably modified by their influence upon one another. It is quite manifest then that a molecule, in order to exist, must maintain a certain equilibrium and harmony between these various motions, and that there can be all degrees of equilibrium from the very stable to that which may be upset by the least disturbing influence from without.

It seems to me that herein we have a full and satisfactory means of explaining the various problems connected with the conception of valence. The question as to whether the atoms of two elements will unite is decided by affinity, which is in some way connected with the electrical condition of these atoms. There is no apparent connection between this and valence. The number of atoms which enter into combination forming one molecule is purely a matter of equilibrium and is dependent upon the motion of those atoms. Thus a phosphorus atom unites with chlorine atoms because of a certain affin-

ity between them. The number of chlorine atoms with which it will unite depends upon the possibility of harmonizing the respective motions. As the temperature may affect these motions and also impart a more rapid molecular motion, it is evident that the harmony, or equilibrium, will depend upon the temperature and that a temperature may be reached at which no harmony is possible and hence no compound can be formed. The phosphorus atom mentioned can, as we know, form a stable molecule with five atoms of chlorine. On increasing the temperature this becomes unstable and only three atoms can be retained. Neither with four atoms nor with two is there harmony of motion. A sufficiently high temperature may prevent any harmony of motion whatever being attained and hence union may become impossible.

As to other influences than those of temperature, we can see that the equilibrium between the atom of phosphorus and the five atoms af chlorine may be upset by such a molecule coming within the influence, electrical or vibratory, of a molecule of water. The atoms must rearrange themselves for a new state of equilibrium and so an atom of oxygen takes the place of two atoms of chlorine, giving again a condition of harmony. In other cases the motion of the molecule of water may be of such a character as to directly harmonize with that of the original molecule and so to enter into equilibrium with it, a definite number of such molecules of water affording a condition of maximum stability. This we call water of crystallization. Such molecules would be more or less easily separated by an increase of temperature and where several molecules of water were attached the highest temperature would be necessary for freeing the original molecule from the last water molecule.

A carbon atom finds its most perfect state of equilibrium where four atoms of hydrogen or their equivalent move in harmony with it. But there is a second state of equilibrium where only half that number of atoms are moving with it. This state does not seem to be a possibility where there are hydrogen atoms but is readily possible where the equivalent number of oxygen atoms is concerned. Such a molecule, how-

ever, is always in a condition to take up additional atoms until its highest equilibrium is reached and in doing this it proceeds by the regular steps needed for bringing about a harmony of motion. A molecule in a lower state of equilibrium we have become accustomed to call unsaturated, calling that one saturated which is in its highest state of equilibrium. The further application of this hypothesis is easily made and need not be dwelt upon here. It will be helpful in many ways.

This theory of valence makes it clear why it should vary toward the same element under different conditions. It is also clear that it might vary towards different elements as these are very possibly possessed of different motions. It is further evident that it is in accord with the conclusion that valence is not an inherent property of the individual atom but is the resultant of the influence upon each other of the combining atoms.

Only one point remains to be considered: Why do the elements of the same group have practically the same valence? The nearest answer to this, and it seems satisfactory, is that they are all possessed of the same phase or kind of motion. In other words the natural division into periods gives us seven or eight more or less different phases. These are, in large measure, independent of the atomic weight. And so the elements in any given group have the same tendency towards similar states of equilibrium in forming compounds with any other element, as hydrogen or oxygen. Some elements, as copper, mercury, tin, etc., are peculiar in that they may change their phase of motion under certain influences, acting then as if they belonged to different groups and entering into totally different states of equilibrium in forming their compounds.

Lastly it is possible for a combination of atoms of different elements, as NH^4 or CN, to have such molecular and intramolecular motion that, although not in a state of equilibrium themselves, they are capable of entering into such states just as the single atoms of elements do, having apparently similar valence.

I might develop this theory much further but it is unnecessary now. Enough has been said to show that such an appli-

cation of the atomic theory is most highly important as a step towards the clearing up of the problems springing from the conception of valence and from the periodic system.

Note.—Since certain points in this paper require treatment at greater length than was practicable in an address, it will be followed by a second paper elaborating such portions.

THE NATURE OF VALENCE.

[Second Paper.]

As the preceding paper upon this subject was in the form of an address before one of the local sections of the society, the hypothesis as to the cause of valence there suggested was given in outline only and could not be enlarged upon as far as may have been necessary. In the present paper it is proposed to elaborate certain points and to test, as far as possible, the reasonable nature of the hypothesis.

While the whole subject of valence has been much confused, and the use of some of the terms connected with it unfortunate, no part of it has given greater trouble than its variability. This is the very point, however, which affords the best clew to its solution and should therefore be treated at some length.

The most instructive cases of varying valence are those where the variation is shown towards the same element, as in the compounds PCl_3 and PCl_5, $FeCl_2$ and $FeCl_3$, Hg_2O and HgO, CO and CO_2, and many other similar compounds. There are two possible views regarding these. Either the valence varies or the valence remains the same and the differences are explained by some such assumption as that of a state of saturation of the atom and of various unsaturated states.

The terms 'saturated' and 'unsaturated' present a number of anomalies as commonly used. In the first place the term saturated is not always used for that condition of the atom in which it is united with the largest number of other atoms. Thus, ferrous oxide (FeO) is called unsaturated, and ferric oxide (Fe_2O_3) saturated, though there is a larger proportion still of oxygen in ferric acid and the ferrates. The same is true of the three series of manganese and chromium compounds.

Again the term saturated does not carry with it any definite relation to the stability of the compound. Sometimes the compound called unsaturated, and containing the least number of atoms is the most stable, sometimes that with the largest number. Phosphorus trichloride is more stable than the pentachloride, but the pentoxide is more stable than the trioxide. The most stable of the manganese compounds are the so-called unsaturated manganous salts; in the case of chromium it would appear to be the chromic salts. In the case of carbon the saturated compounds are the most stable. It is manifest that these two terms cannot cover all cases of combination for a number of elements. It would seem wiser and simpler then to speak of the valence directly when discussing the elements, as bivalent carbon or quadrivalent carbon; bivalent or trivalent iron, etc. In the case of carbon compounds the terms have acquired a somewhat different meaning and are too thoroughly incorporated in the literature for a change to be suggested. Saturated here means a compound which can take on no further atoms by addition, while an unsaturated compound can have such atoms added.

Certain cases of change of valence, as in cuprous and cupric compounds, mercurous and mercuric, ferrous and ferric, etc., have been looked upon as presenting some peculiar relationships. Such cases are spoken of by some as if they occurred among positive elements only. It is not clear how any distinction can be drawn between these and the classes phosphorus and phosphoric, sulphurous and sulphuric, ni-

trous and nitric, chlorous and chloric, etc. A possible distinction might be made that the more negative the element the greater the number of changes of valence; the more positive the element the less variation in valence is observed. This would be an approximation only.

So great is the difference caused by this variation in the valence that some have even thought it best to arrange what have been called the lower and higher stages under different groups. Thus Mendeléeff placed cuprous copper in Group I, and cupric copper in Group VIII; aurous gold in Group I and auric gold in Group VIII. Such an arrangement would, however, greatly confuse the periodic system. Mercury, thallium, chromium, manganese, phosphorus, arsenic, sulphur, selenium, and others would have to be similarly provided for. It is better to retain them in the positions to which their atomic weights would assign them and to study them more thoroughly, so that we may understand why certain elements, as copper, gold, and mercury show this peculiarity while others closely akin to them, as silver, zinc, and cadmium, do not. In studying the nature of valence from the standpoint of its variability, the means by which these variations can be brought about must have an important bearing upon the subject. There are a number of these agencies.

Light.—It is a matter of common observation that light can bring about physical, and the most varied chemical, transformations. In some cases it is apparent that the transformation is one from a higher to a lower valence or *vice versa*. Thus, certain mercurous compounds can be changed to mercuric.

$$Hg_2O = HgO + Hg.$$

An alcoholic solution of ferric chloride is changed by light to ferrous chloride.

$$2FeCl_3 + C_2H_6O = 2FeCl_2 + C_2H_4O + 2HCl.$$

Ferric oxalate under the influence of light gives off carbon dioxide and becomes ferrous oxalate.

$$Fe_2(C_2O_4)_3 = 2Fe(C_2O_4) + 2CO_2.$$

An alcoholic solution of cupric chloride becomes cuprous

chloride. Mercuric chloride in aqueous solution is slowly changed to mercurous when exposed to the light.

$$2HgCl_2 + H_2O = 2HgCl + 2HCl + O.$$

Gold chloride ($AuCl_3$), in contact with organic substances, when exposed to light, is changed first to aurous chloride (AuCl) and then to metallic gold.

It is quite well known that a ray of light falling upon a piece of selenium changes its conducting power for electricity. This is not a change of valence but has, it would seem, its bearing upon the problem as a possible change in vibration. The chemical action of light is generally attributed to the vibrations set up among the molecules. Rays having the shortest wave-lengths and the greatest frequency are most active in this respect though all the rays of the visible spectrum have been shown to exert some action. So far as this variation in valence is caused by light then the hypothesis of a change in vibration necessitating a change in equilibrium may well serve as an explanation.

Heat.—Again these variations are often easily brought about by changes of temperature. Thus cupric chloride becomes cuprous chloride.

$$CuCl_2 = CuCl + Cl.$$

Mercurous chloride is temporarily changed into mercuric, the mercurous re-forming upon cooling.

$$2HgCl = Hg + HgCl_2.$$

Phosphorus pentachloride becomes the trichloride.

$$PCl_5 = PCl_3 + Cl_2.$$

Arsenic pentoxide becomes trioxide.

$$As_2O_5 = As_2O_3 + O_2.$$

An interesting series of changes are those in the sulphur chlorides. Thus sulphur tetrachloride (SCl_4) becomes sulphur dichlorine (SCl_2), if warmed above -22^0, and this becomes sulphur monochloride (S_2Cl_2), if heated above 64^0. This last can be boiled without change.

These instances might be multiplied but it is not necessary. The most plausible explanation offered as to the effect of

heat is a change in the velocity of vibration, and it may well serve to explain the variations caused in valence.

Electricity.—Changes of valence due to electricity are probably not unusual but few observations concerning them have been recorded. One of the most noteworthy is the production of carbon monoxide from carbon dioxide by the passage of the electric spark.

$$CO_2 = CO + O.$$

Chemical Action.—The most usual method of bringing about a change of valence is by chemical action. When the change is from a higher proportion of the negative element to a lower it is commonly called *reduction*, and the reverse change is spoken of as *oxidation*. These terms are apparently relics of an older theory, and are confusing, especially to a student beginning the study of chemistry. They should be limited to cases of the actual removal or addition of oxygen. Thus, to speak of the change of ferrous to ferric chloride by the action of chlorine as an oxidation is careless and incorrect.

$$FeCl_2 + Cl = FeCl_3.$$

It is pushing the type theory rather far to speak of the salts of one valence as being derived from the oxide of that valence and yet this is frequently done.

When we take ferric chloride and let sulphurous acid act upon it, it is called a reduction of the ferric chloride to ferrous chloride, although certainly no oxygen is removed from the ferric chloride nor is oxygen added when the ferrous chloride is changed again to ferric chloride by the action of nitric acid, and still this is called an oxidation. The use of terms for these reactions is evidently in need of revision. What shall we call the following reaction, cited by Drechsel as an "oxidizing action?"

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 = 5Fe_2(SO_4)_3 + K_2SO_4 + 2MnSO_4 + 8H_2O.$$

Some hydrogen is oxidized with the formation of water but that is not what is meant. The manganese is changed from its highest valency to its lowest and the iron from its low-

est to a higher. The permanganate is of course deoxidized.

It seems that chemical action may induce change when to an existing molecule a third substance is offered capable of combining with one or more of its constituent atoms, thus releasing the former equilibrium. Thus when sulphurous acid takes the oxygen of water setting hydrogen free the hydrogen then takes one of the chlorine atoms held by the iron.

$$FeCl_3+H_2SO_3+H_2O=H_2SO_4.2HCl+2FeCl_2.$$

But the presence of all three of these molecules is needed for the reaction to take place. So too, potassium permanganate is stable in the presence of sulphuric acid, unless the ferrous sulphate or some such molecules are present. When molecules of these three substances come together there is immediate rearrangement of molecules with change of equilibrium. Whether we are dealing here with a play of affinity which causes the tumbling down of certain molecules and building up of others, or whether it is a question of vibratory equilibrium between these molecules, cannot yet be told. The only certain thing seems to be that a molecule containing bivalent iron and another containing septivalent manganese cannot exist in the presence of one another but must change, when possible, to trivalent iron and bivalent manganese.

As meagre as our present knowledge is, it does not seem to be a very hopeful task to enter the maze of changes of valence through chemical reactions with a view to clearing up the ideas as to the nature of valence.

Explanations Offered.—Victor Meyer and Riecke have supposed that a solution of the problem could be arrived at best by studying the phenomena of frictional electricity, contact electricity, pyro-electricity, and electrolytic conductivity. Most of those who have suggested hypotheses have based them upon a study of the carbon atom and its compounds and in particular its space relations. I have gathered together such of these hypotheses as have come to my notice.

The first in point of time is the hypothesis of van't Hoff[1].

[1] Ansichten über die organische Chemie I. 3.

His idea is that valence is dependent upon the form of the atom. He says; "The simplest observation teaches that every change from the spherical form must lead to greater changes in the attraction in certain directions, since the atom at these points can, so to say, be more closely approached. Each form of that kind therefore determines a certain number of capacities for attraction or valences."

Ostwald[1] comments upon this hypothesis as follows:

"If we think of valence as a question of a property of the atom, whose action can be modified by the difference in the condition of the atom, especially in its motion, then it is thinkable that although the cause of the valence is unchangeable, the workings of this cause, that is the valence itself seems to differ from case to case.

An hypothesis of this kind has in fact been suggested by van't Hoff. In that he assumed that the chemical attraction between the atoms was a consequence of gravitation, he showed that if an atom possessed a form differing from the spherical the intensity of the attraction on its surface must possess a definite number of Maxima. The Maxima can be of varying value. If the motion of the atom from heat is energetic only the greatest Maxima will be able to hold their atoms and the valence shows itself to be smaller by higher temperatnres than by lower which corresponds with observation.

Lossen's[2] idea as to valence, deduced from the consideration of the theories of van't Hoff and Wislicenus as to the space relations of the atom, seem to be condensed into the simple sentence:

"This conception leads, in my opinion, necessarily to the assumption that the polyvalent atom cannot be regarded as a material point but that rather parts of it are to be distinguished from which the influence goes out to other atoms."

Wislicenus[3] expressed his ideas as to valence as follows:

"I consider it not impossible that the carbon atom more or

[1] Lehrbuch der allg. Chemie I ed. I, 830.

[2] Ber. d. Chem. Ges. 20, 3309.

[3] Ber. d. Chem. Ges. 21, 581.

less, perhaps right closely, resembles in its form a regular tetrahedron; and further that the cause of those influences which reveal themselves as units of affinity concentrate themselves in the corners of this tetrahedron herhaps, and from analogous grounds, just as the electric influences would do from an electrically charged metallic tetrahedron. The real carriers of this energy would be the primitive atoms as the chemical energy of a compound radical is undoubtedly the resultant inherent energy of the elementary atoms.

Victor Meyer and Riecke[1] advanced the hypothesis that the atom is surrounded with a spherical shell of ether: the atom is the seat of chemical affinity, the surface of the ether shell that of valence. Each valence is determined by the presence of two oppositely electrified poles which form the ends of a line short in comparison with the thickness of the shell.

The hypothesis of Knorr[2] may also be given in brief. He assumes in each atom the presence of Valenzkörper which have the power of attracting other Valenzkörper. The quantivalence of any atom is determined by the number of these present.

Flawitzky[3] takes as a basis for his hypothesis the suggestion of N. Beketoff that the cause of the chemical interaction of the elements lay in the interference or coincidence of the motions of the atoms. The chief assumption is that the atoms of each element described closed curves which lie in planes, which are parallel to one another and have a constant absolute position in space. The atoms of different elements move in planes which made definite constant angles with one another. According to Flawitzky, thus, "the valences of the elements can be refered to the differences in the angles between the planes of the paths of the different atoms."

It is quite possible that other hypotheses as to valence have been formulated but have escaped my notice. These

[1] Ber. d. Chem. Ges. 21, 951.

[2] Ann. Chem. (Liegbig) 279, 202.

[3] Ztchr. Amorg. Chem. 12, 182.

will suffice to give the more recent trend of thought upon the subject. I may state that none of these were known to me when the first paper was sent on for publication[1] as I had not deemed it necessary to look beyond the usual text-books in examining into the literature upon the subject. This statement is not made for personal reasons as that is a matter of small moment, but that there may attach to my hypothesis whatever of value there is in the independent reaching of a conclusion.

It is not pertinent to this paper to discuss at any length the citations just given. But a few words are needed to bring out certain differences and distinctions. In most of them we have the assumption of some peculiar form of energy—an "Anziehungskraft." Flawitzky alone makes no explicit assumption of the kind. Besides this assumed force, which is the point of contention after all, we have various other assumptions of a remarkable character; *e. g.*, as to the forms of atoms, envelopes, primal atoms, and *Valenzkörper*. Flawitzky's hypothesis is based upon the angles made between the planes in which the atoms move.

Now in the place of all this I wish to substitute that which seems to me to be the simpler hypothesis of vibratory equilibrium. There is only one attractive force to be considered and this is called chemical affinity and causes the union of the atoms, binding them together. These atoms may unite atom with atom,or one atom with two or three or more atoms of the other element or other elements. While we speak of union there is no actual contact to be assumed. The individual atoms have their own motion and at the same time the aggregation of atoms, or molecule, has a motion proper to it. The conditions of equilibrium in such a system determine the number of atoms which can enter it: as one to one, one to two, etc. There is no distinct force of valence determining this. The form of the atoms can scarcely be taken into consideration because the distance between the atoms is too great, compared with the mass of the atom, for the form

[1] In the Journal of the American Chemical Society.

to exert much influence, unless it influences the character of the motion. The atomic weight also has little influence in determining the number of atoms needed to satisfy the conditions of equilibrium except that there seems to be a general rule that with increase in the atomic weight in any one group more stable equilibrium is brought about with the smaller number of atoms and in a choice between several the lesser valence is preferred. (Compare nitrogen and bismuth; sulphur and tellurium.)

There would then appear to be seven, possibly eight, different kinds of motion among the atoms. Different velocities of vibration are not meant, but different phases of motion. For instance, all may have elliptical orbits with different focal distances; or circular, with different radii, etc. In any group of elements the motion of the atoms would have one common characteristic but there would be differences in velocity. In the first and seventh group, showing, for the most part, a tendency towards the same equilibrium, or having the same valence, the motion must be closely analogous. So too for the second and sixth groups, the third and fifth. There may then be a necessity for four distinct phases only, unless we suppose a fifth for the eighth group. If the motion of an atom can be changed from one character to another its valence is changed and in such general properties as are dependent upon motion and not upon atomic weight it is equivalent to changing its group. Electricity, light, heat, and chemical action can cause this change of motion. In so far the properties of the element are subject to change and within our control. But the other factor, atomic weight, with the properties of the element determined by it, is not subject to change nor within our control, so far as our knowledge goes.

While it is freely granted that there is so much of the speculative in what has been said as to make us touch the whole subject with extreme caution, and while it is further admitted that it is quite beyond the reach of present experimental research, yet it is believed that the use of the imagination is legitimate and tends toward the advancement of the science

so long as the true value is set upon it and fancy is not allowed to obscure fact nor to be mistaken for it. The hypothesis proposed is simple and if true will be very helpful. It will be a great step forward if it can be shown that the doctrine of valence is a doctrine of vibratory equilibrium.

PRELIMINARY CATALOGUE OF THE BIRDS OF CHAPEL HILL, N. C., WITH BRIEF NOTES ON SOME OF THE SPECIES.

T. Gilbert Pearson.

INTRODUCTION.

In this catalogue are enumerated the species of birds, known to have been observed and positively identified at Chapel Hill. While the list is incomplete, and is presented only as a preliminary catalogue, the author expresses the hope that it may prove of use to those interested in the ornithology of the region, and that it may serve as a basis for more extended observations. In addition to the enumeration of the species, the paper contains some brief notes on the migration and nesting habits of such forms as have come under the writer's observation at Chapel Hill.

The difficulty of preparing a complete catalogue of the birds may be readily understood when we recall the fact that the bird population is constantly changing. The great wave of the autumnal migration carrying large numbers of northern birds past us, at the same time taking many of our summer forms, scarcely subsides, before the swell sets back from the south, sweeping hosts of birds of passage to us on their northern journey. Some migrants found to be numerous during the fall migration may be extremely rare in the spring, and *vice versa*. Birds which normally do not occur in a

region are sometimes taken, having wandered, or having been driven by storms far out of their natural range. In certain species some individuals are always migratory, while others are permanent residents.

Again it is well known that a form which is abundant some years, may be seen but rarely or not at all in after years. The changing area of the food products for birds naturally brings about a change in the area of their habitat. Hence it may easily be seen that continual observation during a number of years is absolutely necessary before anything like a complete list of the *avi-fauna* of a particular region can be hoped for.

Data.—My observations on the bird life of Chapel Hill began in September 1897, and were continued up to the following April; then again from September 1898 until June 1899. With the exception of ten days in the latter part of June 1898, I had no opportunity for studying the region in summer. During the fall migration in 1897, the main part of which extended over the month from September 15 to October 15, a portion of twenty-one days was spent in the field in a special study of the warblers. Sixteen species of warblers were secured during this period.

In gathering material for the catalogue much assistance was rendered by members of my ornithology class at the University of North Carolina, in 1898, and again during the spring of 1899. Of those whose aid has been especially valuable, I would mention Mr. George McNider, Mr. E. H. Hartley and Mr. Ivy Lewis. I am indebted also to Dr. Kemp P. Battle, whose close observations on the birds of the neighborhood, extending over a period of many years, I found very valuable.

In the Journal of the Elisha Mitchell Scientific Society, Part 2 for 1887, Prof. George F. Atkinson published a "Preliminary Catalogue of the Birds of North Carolina," in the preface of which he remarks, "In all, about 120 species have been observed and absolutely identified by myself at Chapel Hill." In his catalogue, however, Professor Atkinson omits

to indicate the species which he had there noted. A clipping from the "Raleigh News and Observer," presumably printed about this time has been kindly loaned me by Mrs. R. W. McRae. The clipping contains a "Preliminary list of birds collected in the vicinity of Chapel Hill," by Professor Atkinson. In this communication are enumerated ninety-two species. Two of the forms there mentioned have not been included in the present list. The first of these, the tame pigeon (*Columbia livia domesticata*), is excluded as not being a native wild bird. The other form, the clay-colored sparrow (*Spizella pallida*), was listed by Professor Atkinson on the strength of a single specimen. This specimen is still preserved in the Biological Laboratory, and is a fair type of the swamp sparrow (*Melospiza georgiana*). In the case of all other birds, included in the News and Observer list, and with which I have not myself met, mention is made of Professor Atkinson as the observer.

My own observation in the field, specimens brought in by others from time to time for identification, and Professor Atkinson's two papers, constitute the data, from which the present list has been compiled. In all one hundred and nineteen species of birds at Chapel Hill have actually come under my notice.

It may be of use to mention here some of the collections of birds now in North Carolina, which are accessible to the public. In the Biological Laboratory at the State University, in Chapel Hill, there is a collection of some 350 skins and mounted specimens. The State Agricultural Museum at Raleigh contains a beautiful collection of several hundred mounted birds. The collection of birds in the Museum of Natural History at Guilford College is numerically nearly as great. All of these collections are constantly growing.

The Field.—The field for the study of bird life about Chapel Hill is in many respects a good one. The woods, open fields, small streams, and underbrush make a varied environment which tends to bring together large numbers of forms. On the other hand the absence, in the immediate

neighborhood, of large streams and ponds, keeps away many varieties of ducks, sandpipers, and birds of similar habits.

Terms used.—The nomenclature adopted by the American Ornithologists' Union is followed, and the vernacular name succeeds the scientific. In some cases well known local names are also added. The terms "common," "rare," "abundant," etc., which are used in speaking of the occurrence of birds, are of course relative and not altogether satisfactory, but they may convey something of the original idea intended.

Family Podicipidae.

1. COLYMBUS HOLBOELLII (Reinh.) Holboell's Grebe. One specimen recorded by Prof. Atkinson, taken at Chapel Hill in 1877. The skin is now preserved in the university collection.

2. PODILYMBUS PODICEPS (Linn.) Pied-billed Grebe; Dieдapper; Water-witch. One was shot near town and brought me on November 3, 1897. Others have been taken but the bird probably occurs only in winter.

Family Urinatoridae.

3. URINATOR IMBER (Gunn.) Loon; Great Northern Diver. Occurs only as a migrant or winter visitor. the two specimens in the university collection bear no date of capture.

Family Anatidae.

4. SIX SPONSA (Linn.) Wood Duck; Summer Ruck. A male in fine plumage was killed in "Strowd's low-grounds" from a small flock by Mr. H. E. Mechling on January 3, 1898. Others have been reported at various times. Possibly breeds.

Family Ardeidae.

5. BOTAURUS LENTIGINOSUS (Montag.) American Bittern; Thunder Pumper. Recorded by Prof. Atkinson as occurring at Chapel Hill.

6. ARDEA HERODIAS (Linn.) Great Blue Heron; Blue Crane. "These birds used to fly over here years ago but I have not noticed one, I am sure, for the past twenty years." —Dr. Kemp P. Battle.

7. Ardea egretta (Gmel.) American Egret. A specimen was shot north of the village by the late Mr. Dedrick in 1894. Doubtless a rare summer straggler.

8. Ardea virescens (Linn.) Green Heron. A common summer resident about the mill-ponds and along the creeks. A nest containing fresh eggs was found near the village by Mr. George McNider during the first week of May 1899.

Family Rallidae

9. Porzana carolina (Linn.) Sora. One in the university collection was taken in November 1887, at Chapel Hill.

10. Fulica americana (Gmel.) American Coot; Blue Peter. The only record is by Prof. Atkinson. "One walked into Mr. McCauley's store at Chapel Hill on the night of April 8, 1887, at 8 o'clock, and was captured. A heavy wind and storm was prevailing, and had continued all day."

Family Scolopacidae.

11. Philohela minor (Gmel.) American Woodcock. A rather common resident, but owing to its very retiring habits is not often seen. Noticed one on the University campus November 10, 1898.

12. Gallinago delicata (Ord.) Wilson's Snipe; English Snipe. Not uncommon in winter and during migration.

13. Totanus solitarius (Wils.) Solitary Sandpiper. Listed by Prof. Atkinson. This bird probably appears at Chapel Hill only as a migrant or occasional winter visitor.

14. Actitis macularia (Linn.) Spotted Sandpiper. Catalogued by Prof. Atkinson. Its habits are quite similar to those of the Solitary.

Family Charidriidae.

15. Aegialitis vocifera (Linn.) Killdeer. The killdeer is commonly met with during the fall and winter months. It is highly probable, however, that it is a regular resident, nesting in favorable localities in the surrounding country.

Family Tetraonidae.

16. Colinus virginianus (Linn.) Bob-white; Quail; Partridge. An abundant resident at all times of the year.

Family Phasianidae.

17. MELEAGRIS GALLOPAVO (Linn.) Wild Turkey. A resident at Chapel Hill. Have seen seven specimens. Four of these were shot near town, and three I observed alive. In November, 1898, one flew across the campus from the southern side and pitched near the Episcopal church building. They haunt at all seasons the large tract of woodland just south of the University, and quite likely construct their nests in some of the sedge fields near by.

Family Columbae.

18. ZENAIDURA MACROURA (Linn.) Mourning Dove. Of common occurrence at all seasons. Its frail nest containing two pure white eggs may often be found on the boughs of the apple-tree or the horizontal limbs of the pine.

Family Cathartidae.

19. CATHARTES AURA (Linn.) Turkey Vulture; Turkey Buzzard. A very common bird at all seasons of the year, rearing its young usually in hollow logs or stumps in the deep woods.

20. CATHARISTA ATRATA (Bartr.) Black Vulture; South Carolina Buzzard. Watched a flock of Black Vultures flying northward over the campus November 1, 1897. On November 10 others were seen. During the winter of 1898–'99 these birds again appeared in the neighborhood. It is doubtful if they ever breed in this region.

Family Falconidae.

21. CIRCUS HUDSONIUS (Linn.) March Hawk. An adult male was shot one mile east of town and brought to me on April 5, 1899. This is the only record for Chapel Hill.

22. ACCIPITER VELOX (Wils.) Sharp-shinned Hawk. A rather rare winter visitor. The mounted specimen in the University collection was shot by Mr. George McNider on January 23, 1898.

23. ACCIPITER COOPERI (Bonap.) Cooper's Hawk. A common resident. A nest of fresh eggs was taken by Mr. George

McNider on April 29, 1898. This is the hawk whose inroads on the poultry yard are most destructive.

24. BUTEO LINEATUR (Gmel.) Red-shouldered Hawk. While it seems reasonable to think this would be a common bird here only one pair have come to my notice. During the spring of 1898 a pair were often watched as they circled through the air above the grove south of the University campus.

On May 9, 1899, I took from their nest in a pine tree, thirty feet from the ground, a clutch of two handsomely marked eggs. Incubation was well advanced at this date.

25. BUTEO LATISSIMUS (Wils.) Broad-winged Hawk. The only one of this species known to have been taken at Chapel Hill is the one brought to me for identification by Mr. George McNider on April 15, 1899, which specimen is still retained in his private collection. It was a female and was shot a few miles south of here. Its stomach contained the remains of a frog and a quantity of bird feathers.

26. HALIAEERUS LEUCOCEPHALUS (Linn.) Bald Eagle; American Eagle. On March 27, 1898, I watched an adult bald eagle circling about in the air near the northwestern entrance of Battle's Park. As the bird was not over one hundred yards above the earth at the time, its white head, neck and tail could be easily seen. It must be regarded as a very rare bird in this section.

27. FALCO SPARVERIUS (Linn.) American Sparrow Hawk. A moderately common resident hawk. Three fresh eggs were found in a nest located in the cavity of a dead pine tree in May, 1898, by Mr. E. H. Hartley. For the past two years a pair of these birds have spent the winter months on the University campus. Their favorite roost was under the eaves of the New East Building.

Family Beronidae.

28. SYRNIUM NEBULOSUM (Forst.) Barred Owl; Hoot Owl. Have frequently heard them calling in Battle's Park, and January 18, 1899, a male, which had been wounded, was brought into the Biological Laboratory.

29. MAGASCOPS ASIO (Linn.) Little Screech Owl. The

shivering notes of this little owl may be heard about the groves and campus during all seasons of the year. Especially is this true in the late summer when the young of the year, then about grown, join with their parents in the nightly serenade. Their nests are placed in the hollows of trees.

30. Bulo Virginianus (Gmel.) Great Horned Owl. For a large bird the horned owl is a fairly common resident in this region. Its domicile is usually located in the natural cavity of some tree or in an old hawk or crow's nest. The eggs are deposited early in the year. A female shot on January 21, 1899, contained two well developed ovarian eggs.

Family Cuculidae.

31. Coccyzus Americanus (Linn.) Yellow-billed Cuckoo; Rain Crow. A well known plaintive cry from orchard and forest is the note of the rain crow in summer. It retires to the south on the approach of autumn.

Family Alcedinidae.

32. Ceryle alcyon (Linn.) Belted Kigfisher. Observed occurring along the creeks in autumn, winter and spring. May possibly breed.

Family Picidae.

33. Dryobates villosus audubonii (Var?) Hairy Woodpecker. Two specimens were taken during the winter of 1897–'98. It is probably a rare resident.

34, Dryobates pubescens (Linn.) Downy Woodpecker. An abundant resident, associating often with the Titmouse and Chicadee. The downy spends the long winter nights in holes which it hollows out of the dead limbs of trees for this purpose.

35. Sphyrapicus varius (Linn.) Yellow-bellied Sapsucker. A common winter form. It often girdles trees with numerous small holes which it drills for the purpose of drinking the sap. The apple, spruce pine and maple are among the trees which thus suffer.

36. Ceophloeus pileatus (Linn.) Pileated Woodpecker.

This large handsome woodpecker is not an uncommon bird in Battle's Park and adjoining woods. On November 8, 1897, I watched one for many minutes pecking about on the trees in the college campus. Without doubt the bird breeds in the large timber near by.

37. MELANERPES ERYTHROCEPHALUS (Linn.) Red-headed Woodpecker. A resident. Locally and occasionally common.

38. MELANERPES CAROLINUS (Linn.) Red-bellied Woodpecker. This large spotted "sapsucker" is a not abundant resident with us at all seasons.

39. COLAPTES AURATUS (Linn.) Flicker; Yellow Hammer. An abundant resident. This woodpecker has acquired the habit of procuring its food so largely by digging it out of the earth that it may now be regarded as more of a ground bird than a dweller in trees.

Family Caprimulgidae.

40. ANTROSTOMUS CAROLINENSIS (Gmel.) Chuck-will's-widow. On the night of May 20, 1899, I listened to one of these birds calling for over half an hour. It seems to be in the neighborhood of the campus wall near the south-east corner. So far as I am aware this is the only record of its occurrence in Chapel Hill. It may possibly be found to be a rare summer resident in Orange county.

41. ANTROSTOMUS VOCIFERUS (Wils.) Whip-poor-will. A common summer visitor, depositing its two marble looking eggs on the ground in the woods, with only a few dead leaves between them and the earth. The first one noted in the spring of 1899 announced its arrival from the south by its loud cry on the night of April 20.

42. CHORDEILES VIRGINIANUS (Gmel.) Nighthawk; Bull-bat. A common spring and autumn transient. A few may linger through the summer to breed. First one seen in 1899 was in the afternoon of April 27.

Family Micropodidae.

43. CHAETURA PELAGICA (Linn.) Chimney Swift; Chimney

Swallow. A common summer resident, arriving from the south early in April. First one noted for 1899 was on April 12. Before the white man came with his chimneys the swift built its nest in hollow trees.

Family Trochilidae.

44. TROCHILUS COLUBRIS (Linn.) Ruby-throated Hummingbird. Of the four hundred species of hummingbird known to occur in America, the ruby-throat is the only one found east of the Mississippi. It is a common summer resident at Chapel Hill, arriving during the latter half of April.

Family Tyrannidae.

45. TYRANNUS TYRANNUS (Linn.) Kingbird; Bee Martin. This little pugilist, which does not hesitate to attack any intruder which comes near its nest, is a common summer resident about Chapel Hill.

46. MYIARCHUS CRINITUS (Linn.) Crested Flycatcher. An abundant summer resident, building its nest in cavities of trees or stumps seldom more than twenty feet from the ground. The bird has the habit of using among its other nesting materials a cast snake skin. First arrival for 1899 noted April 21.

47. SAYORNIS PHOEBE (Lath.) Phoebe; Pewee. Summer resident. First noted in 1899 on April 30. Eggs have been taken by Mr. McNider.

48. CONTOPUS VIRENS (Linn.) Wood Pewee. Common summer visitor.

49. EMPIDONAX VERESCENS (Vieill.) Acadian Flycatcher. Listed for Chapel Hill by Prof. Atkinson. Probably a common summer bird.

Family Aladidae.

50. OTOCORIS ALPESTRIS (Linn.) Horned Lark; Shore Lark. Two specimens were brought me on November 23, 1898. They were said to have been shot from a flock of about twenty individuals. This bird can be expected only as an irregular winter visitor.

Family Corvidae.

51. CYANOCITTA CRISTATA (Linn.) Blue Jay. An abundant resident, nesting in large numbers in the trees about the campus and village. A set of five eggs taken from a nest on May 11, 1899, were slightly incubated.

52. CORVUS AMERICANUS (Aud.) American Crow. Common bird. Breeds in numbers.

53. DOLICHONYX ORYZIORUS (Linn.) Bobolink; Reedbird; Ricebird. Occurs as a fall and spring migrant, but not a common species at any time. I noticed a flock of six individuals consisting of two males and four females on the campus May 20, 1899.

54. AGELAIUS PHOENICEUS (Linn.) Red-winged Blackbird. A resident, but never a very abundant bird. It builds its nest in the bushes and trees along creeks.

55. STURNELLA MAGNA. Meadowlark; Old Field Lark. Of common occurrence in autumn and winter. During the winter months of 1898–'99 a flock of about forty individuals remained constantly on the college campus. The birds may possibly breed in limited numbers in this region.

56. ICTERUS SPURIUS (Linn.) Orchard Oriole. Not an uncommon spring visitor, and very probably remains through the summer to nest.

57. SCOLECOPHAGUS CAROLINUS (Mull.) Rusty Blackbird. Two were shot by Mr. Ivy Lewis on Februrary 3, 1899, from a small flock, which was feeding along the branch in the grove just south of the campus. Later in the month several others were seen.

58. QUISCULUS QUISCULA (Linn.) Purple Grakle. Mr. McNider noted a small flock of these on Easter Monday, 1898. On December 28, 1898, I saw one on the college campus. They probably do not spend the summer in Orange county.

Family Fringillidae.

59. CARPODACUS PURPUREUS (Gmel.) Purple Finch. An abundant winter resident. They appear to have a great relish for the buds of the wahoo or winged elm (*Ulmus alata*) and may often be seen in large numbers feeding on these trees.

60. Passer domesticus (Linn.) House Sparrow; English Sparrow. An abundant resident. They multiply rapidly, each pair of birds raising several broods in a season.

61. Spinus tristis (Linn.) American Goldfinch; Yellow-bird; Lettuce bird. A familiar bird throughout the year.

62. Poocaetes gramineus (Gmel.) Vesper Sparrow; Bay-winged Bunting. Winter visitor, rather rare.

63. Ammodmramus sandwichensis savanna (Wils.) Savanna Sparrow. Common winter visitor.

64. Ammodramus savannarum passerinus (Wils.) Grasshopper Sparrow. Seen in winter and spring. A few may breed.

65. Zonotrichia albicollis (Gmel.) White-throated Sparrow. An abundant winter sojourner, associating in flocks often in company with the snowbird (*Junco*). Earliest arrival noted in 1897 was on October 4.

66. Spizella monticola (Gmel.) Tree Sparrow. Listed by Prof. Atkinson probably as a winter occurence.

67. Spizella socialis (Wils.) Cnipping Sparrow. One of our most abundant summer birds, building its nest in the trees and bushes about the campus. First spring arrival for 1899 was seen on April 11.

68. Spizella pusilla (Wils.) Field Sparrow. Common summer resident. It nests in low bushes or on the ground.

69. Junco hyemalis (Linn.) Slate-colored Junco; Snowbird. This is one of our best known winter friends, and is met with in numbers from the time of its arrival late in the autumn until the warm April days. It then leaves for its summer home in the north. There is a common saying about the country that this bird in the spring turns to a sparrow, and in the fall of the year again assumes the dark coat and hood of the snowbird. My first record of its arrival in the fall of 1897 is October 30.

70. Peucae aestivalis bachmanii (Aud.) Bachman's Sparrow. "One taken from a breeding pair by myself at Chapel Hill. The nest was found by Willie Gullick; eggs 4, size .63x.70, dull whitish; nest a bulky structure on the

ground made of coarse grasses."—*Atkinson's Catalogue.* It is probably a regular summer resident.

71. MELOSPIZA FASCIATA (Gmel.) Song Sparrow. A common winter visitor. Its strong clear song is one of the characteristic notes of a winter's evening in the fields about Chapel Hill.

72. MELOSPIZA GEORGIANA (Lath.) Swamp Sparrow. A common winter visitor.

73. PASSERELLA ILIACA (Merr.) Fox Sparrow. This handsome brown fellow, the largest of all our sparrows, is a common though not an abundant winter bird. It avoids the open fields and may be found along the borders of thickets and in shrubbery. The first one seen by myself in the fall of 1897 was on November 17.

74. PIPILO ERYTHROPHTHALMUS (Linn.) Towhee; Chewink; Swamp Robin. This is a common bird during the migrations, haunting the thickets and the border of wooded streams.

75. CARDINALIS CARDINALIS (Linn.) Cardinal; Redbird. These beautiful and interesting birds are constant residents in this region. Their nests, composed mainly of twigs and leaves and lined with rootlets are generally situated in small trees. Three or four is the number of eggs deposited. May is the usual month for breeding.

76. HABIA LUDOVICIANA (Linn.) Rose-breasted Grosbeak. A rare spring transient.

77. GUIRACA CAERULEA (Linn.) Blue Grosbeak. Recorded by Prof. Atkinson. Found to occur only in the summer.

78. PASSERINA CYANEA (Linn.) Indigo Bunting; Indigo-bird. An abundant summer resident, building its nest in small trees and bushes a few feet from the ground.

Family Tanagridae.

79. PIRANGA ERYTHROMELAS (Vieill.) Scarlet Tanager. Rather a rare spring transient. Have seen them in April and May.

80. PIRANGA RUBRA (Linn.) Summer Tanager; Summer

Red-bird. An abundant and conspicuous denizen of the groves and orchards in summer. It constructs a nest of leaves, small strips of bark, and grass, situated usually on a horizontal limb from ten to twenty feet from the ground.

Family Hirundinidae.

81. PROGNE SUBIS (Linn.) Purple Martin. Have seen only a few. These came as spring migrants. They would likely spend the summer and breed, if suitable nesting places, such as bird boxes on poles, were furnished them. I know of none that nest here, nearer than eight miles from town. Dr. Kemp P. Battle informs me that forty years ago these birds were common summer residents.

82. CHELIDON ERYTHROGASTER (Bodd.) Barn Swallow. Common transient.

83. TACHYCINETA BICOLOR (Vieill.) Tree Swallow; White-bellied Swallow. A common spring migrant.

84. STELGIDOPTERYX SERRIPENNIS (Oud.) Rough-winged Swallow. A summer visitor. Eggs secured by Mr. McNider from a hole in a clay bank in June 1899, I believe to be of this species.

Family Ampelidae.

85. AMPELIS CEDRORUM (Vieill.) Cedar Waxwing: Cedar-bird. The sad lisping notes of the cedar-bird is one of the most common sounds in the winter forest. The birds at this season usually associate in flocks of a few dozen individuals, and are often found clinging to the boughs of cedar trees, the berries of which they are very fond of eating. It probably nests here.

Family Laniidae.

86. LANIUS LUDOVICIANUS (Linn.) Loggerhead Shrike. Rather a rare winter visitor. I have observed six individuals at Chapel Hill.

Family Vireonidae.

87. VIREO OLIVACEUS (Linn.) Red-eyed Vireo; "Hanging bird." A common summer form.

88. VIREO FLAVIFRONS (Nieill.) Yellow-throated Vireo. One taken by myself May 20, 1899. Will doubtless be found to be of regular summer occurrence.

89. VIREO SOLITARIUS (Wils.) Blue-headed Vireo. I secured a specimen on October 8, 1897, and within a week three other birds were seen. It may be looked for with success only during the spring and autumn migrations.

90. VIREO NOVEBORACENSIS (Gmel.) White-eyed Vireo. Prof. Atkinson records it as a "rare summer visitor."

Family Mniotiltidae.

91. MNIOTILTA VASIA (Linn.) Black-and-White Creeping-Warbler. Common summer resident, nesting on the ground in the woods. Have found it more numerous during the fall migration. This attractive little white and black striped acrobat is apparently equally at home while searching for food along the under side of a limb, or clinging head downward on the huge bole of some forest tree.

92. HELMITHERUS VERMIVORUS (Gmel.) Worm-eating Warbler. Listed by Prof. Atkinson.

93. COMPSOTHLYPIS AMERICANA (Linn.) Parula Warbler. An abundant species in the spring and autumn. Is doubtless a summer resident also.

94. DENDROICA AESTIVA (Gmel.) Yellow Warbler. Summer resident.

95. DENDROICA CAERULESCEUS (Gmel.) Black-throated Blue Warbler. Common migrants. I have usually found them haunting thickets bordering woodland streams.

96. DENDROICA CORONATA (Linn.) Myrtle Warbler; Yellow-rumped Warbler. Plentiful in fall and spring, some remaining through the winter months.

97. DENDROICA MACULOSA (Gmel.) Magnolia Warbler. I have found this a rare bird at Chapel Hill. Have taken only two specimens, one a male on September 24, 1897, the other a female five days later.

98. DENDROICA PENNSYLVANICA (Linn.) Chestnut-sided Warbler. Found only in transit. Have seen but one bird, it being a male taken on September 21, 1897.

99. DENDROICA CASTANEA (Wils.) Bay-breasted Warbler. On October 2, 1897, about six o'clock in the morning I shot a female *D. castanea* and on October 8, another, a male. They are extremely rare birds, these being not only the first taken at Chapel Hill but are the first recorded in North Carolina. The skins of both specimens are preserved in the university collection.

100. DENDROICA STRIATA (Forst.) Black-poll Warbler. Rather rare transient. Took a female on October 9, 1897.

101. DENDROICA BLACKBURNIAE (Gmel.) Blackburnian Warbler. Have found this only as a rare bird of of passage. Secured a female on October 16, 1897.

102. DENDROICA DOMINICA (Linn.) Yellow-throated Warbler. Spring migrant. Have observed but few.

103. DENROICA VIRENS (Gmel.) Black-throated Green Warbler. I found this not an uncommon fall migrant. Took a female October 2, 1897.

104. DENDROICA VIGORSII (Aud.) Pine Warbler. A common resident. Have not found the nest. The bird is said to build on horizontal limbs of pine trees from twenty to sixty feet from the earth.

105. DENDROICA PALMARUM (Gmel.) Palm Warbler, (more probably the var. *D. p. hypochrysea*, (Ridgw.).) Listed by Prof. Atkinson.

106. DENDROICA DISCOLOR (Vieill.) Prairie Warbler. Summer resident, not uncommon.

107. SEIURUS AUROCAPILLUS (Linn.) Oven-bird; Golden-crowned Thrush. A migrant. First one seen in spring of 1899 was on April 14.

108. SEIURUS NOVEBORA CENSIS (Gmel.) Water-thrush. Not a very common transient. Have only seen a few specimens.

109. SEIURUSMOTA CELLA (Vieill.) Louisiana Water-thrush. Common summer resident. Observed as late in the fall of 1897 as September 21. First one seen in 1899 was on April 12.

110. GEOTHLYPIS TRICHAS (Linn.) Maryland Yellow-throat. A summer bird doubtless breeding here.

111. Icteria virens (Linn.) Yellow-breasted Chat. An abundant summer resident. Found usually along the border of woods or haunting the growths of bushes in open fields along streams.

112. Hooded warbler, Catalogued by Prof. Atkinson. Is probably a rare summer resident.

113. Setophaga ruticulla (Linn.) American Redstart. A common migrant and a rather rare sojourner in summer.

Family Motacillidae.

114. Anthus pennsilvanicus (Lath.) American Pipit; Titlark. About nine o'clock on the morning of January 4, 1899 I saw a flock of fully one hundred titlarks in the open piece of ground at the eastern side of the university campus. Have on two other occasions observed flocks of these birds at a distance, but always during the coldest parts of the winter.

Family Troglodytidae.

115. Mimus polyglottos (Linn.) Mockingbird. Several pairs of these birds are constant residents at Chapel Hill. There is a great difference in the musical power of different birds of this species. An especially fine singer, has for the past two years or more dwelt among the shade trees of the lawns in the neighborhood of the Episcopal church.

116. Galeoscoptes carolinensis (Linn.) Catbird. An abundant species in summer. The first ones arrive from the south near the middle of April.

117. Harporhynchus rufus (Linn.) Brown Thrasher; Brown Thrush. These fine songsters come regularly to spend the summer in the thickets and groves about the village. Rarely also they spend the winter here. On January 2, 1899, I observed one on the lawn surrounding the home of Prof. Harrington. It was in company with a number of snowbirds and sparrows, and had apparently taken up its winter abode among them.

118. Thyothorus ludovicianus (Lath.) This is one of the few species of birds which sing for us in the winter. It

remains here through the summer, breeding abundantly. The nest is made of a great quantity of dried grass, strings, leaves and other materials, and is placed in a wide variety of positions; such as in old tin cans hung up in trees, in knot holes, or under the eaves of houses, and under brush heaps in the woods. On May 17, 1899, I was shown a nest containing six eggs, which was built in a man's cap hung against the slatted side of an out-house.

119. TROGLODYTES AEDON (Vieill.) House Wren. Listed by Prof. Atkinson. Probably a rare transient.

120. TROGLODYTES HIEMALIS (Vieill.) Winter Wren. Common in winter.

121. CERTHIA FAMILIARIS AMERICANA (Bonop.) Brown Creeper. Common in winter, but not abundant.

Family Paridae.

122. SITTA CAROLINENSIS (Lath.) White-breasted Nuthatch. Common resident. Nests in holes in tall trees, early in April.

123. SITTA PUSILLA (Lath.) Brown-headed Nuthatch. Have frequently found them in the pine groves in April and May.

124. PARUS BICOLOR (Linn.) Tufted Titmouse. Common resident. Eggs number from four to six, and are deposited in the cavities of trees.

125. PARUS CAROLINENSIS (Aud.) Carolina Chicadee. A common and noisy resident; often associating in small flocks in company with the titmouse. The nest is made in holes in small trees or posts, from five to light eggs being deposited.

Family Sylvavudae.

126. REGULUS SATRAPA (Litcht.) Golden-crowned Knight A winter resident. It is worth a search in the winter forest to get a glimpe of this most exquisite gem of diminutive bird life, with his olive-green coat and bright orange and yellow crest. His summer home is among the evergreens of the mountains, and of the far north.

127. REGULUS CALENDULA (Linn.) Ruby-crowned Knight. Have found it to be a less abundant species than the foregoing. More common during the migration period.

128. POLIOPTILA CAERULEA (Linn.) Blue-gray Gnatcatcher. Very abundant summer resident, breeding in April and May. Eggs four to six.

Family Turdidae.

129. TURDUS MUSTELINUS (Gmel.) Wood-Thrush; Wood Robin. This is the most abundant and characteristic summer bird of Chapel Hill, building the nest for its four greenish-blue eggs in the shade trees of the lawns and streets. The first arrival noted from the south in the spring of 1899 was one heard singing on April 22.

130. TURDUS FUSCESCENS (Steph.) Wilson's Thrush. Noted by Prof. Atkinson. Probably seen in transit.

131. TURDUS USTULALUS SWANISONII (Cal.) Olive-backed Thrush. Occurs only as a migrant. One specimen taken September 26, another October 9, 1897.

132. TURDUS AONALASCHKAE PALLASII (Cab.) Hermit Thrush. The common winter thrush.

133. MERULA MIGRATORIA (Linn.) American Robin. A well known resident. Breed, building their nests in shade and orchard trees.

134. SIALIA SIALIS (Linn.) Bluebird. Since the severe cold weather early in the year 1893, which proved so destructive to bird life in the Eastern States, the bluebird has been scarce. Of late, however, the species is beginning to assume more nearly its former numbers.

Oct. 1, 1899. *Guilford College, N. C.*

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SIXTEENTH YEAR———PART SECOND

1899

ON THE UNIVERSAL DISTRIBUTION OF TITANIUM.[1]

BY CHARLES BASKERVILLE.

The universal distribution of titanium in the mineral and plant world is practically acknowledged. V. Roussel[2] found it in basalt; Aleksiejew[3] in certain clays. Holland[4] found it in certain igneous rocks. Dunnington[5] observed its occurrence in the soil of Albemarle County, Va.; later the same writer with McCaleb[6] found it in sixteen specimens of soil collected from different sections of the United States. Subsequently after having examined a large number of samples of soil collected from all parts of the globe Professor Dunnington[7] asserted its universal occurrence in the soils of the world.

W. A. Noyes[8] found it in a number of Arkansas minerals. Hillebrand has shown its presence in a large number of rocks and minerals collected by the United States Geological Survey. Wait[9] found it in the ashes of several plants and different

1 *J. Am. Chem. Soc.*, *XXI*, *1099*.
2 *Ber. d. chem. Ges.*, *6*, *1417*, *b*.
3 *Chem. Ztschr.*, Rep. 1896, 261.
4 *Chem. News*, *59*, *27*.
5 *Proc. A. A. A. S.*, *34*, *132*.
6 *Am. Chem. J.*, *10*, *36*.
7 *Am. J. Sci.*, Dec., 1891; *Chem. News*, *65*, *65*.
8 *J. Anal. Appl. Chem.*, *5*, *39*.
9 *J. Am. Chem. Soc.*, 18, 402.

kinds of wood, also in coals, bituminous and anthracite. Haywood[1] found traces in domestic strawberries and 0.1088 per cent. in the ash of wild strawberry (*Fragaria Virginiana*). Langenbeck speaks frequently of its occurrence in clays. It has been found by the writer rather widely distributed in the clays of this state.[2] While Roscoe and Schorlemmer state that "It does not appear to form a part of the animal and vegetable kingdom," Wait[3] assumes that it is assimilated by plants. The writer[4] shows its presence in peat. As the clay substance therein is comparatively small its presence can scarcely be attributed to that. F. Garrigon found traces in mineral waters.

No statement in the literature has been found of its presence being noted in the ashes obtained from the animal kingdom. The ash from incinerated fresh beef, beef bone, human flesh, and bone free from dirt, have been examined in this laboratory with the following results: Beef bone 0.0195 per cent.; beef flesh 0.013 per cent.; human bone[5] a trace; human flesh[6] 0.0325 per cent. titanic oxide.

A private communication from Dr. J. L. Howe concerning the work of some of his students states that "Toole found titanium in abundance in dead bones, but only traces in fresh bone and muscular tissue, though traces were undoubtedly there." Dr. C. E. Wait in a letter of recent date writes: "Since my note on titanium was published a year or so ago, I have made an examination of a large number of bodies and I believe that the element was found in nearly all of them. I have made a large number of estimations of titanium in vegetable bodies, and later took up the examination of animal

1 This laboratory. Work unpublished.

2 See "Clay Deposits and Clay Industry in N. C." Bulletin 13, N. C. Geological Survey, by Dr. H. Ries.

3 *Vide supra.*

4 *J. Am. Chem. Soc.*, 21, 706.

5 A true rib and clavicle.

6 Pectoral muscles, *latissimus dorsi* and *gluteus maximus*. I am indebted to Dr. C. S. Mangum, of this University, for kindly dissecting out these samples.

flesh and bone, and the last piece of work along that line was the examination of human excretory products."

The universal distribution of titanium in all forms of living and dead matter may now be regarded as settled. While no opinion is hazarded by the writer upon the role played by titanium in animal and vegetable growth, it is hoped that Dr. Wait's work will throw some light upon the subject. Doubtless had we as delicate and convenient tests for the other less common elements we should find their occurrence as widespread. Thus the asseverated belief of Hillebrand in the universal occurrence of the elements in the earth's crust is extended.

Titanium was determined by Weller's well-known method as modified by W. A. Noyes, Dunnington, and Hillebrand.[1]

THE OCCURENCE OF VANADIUM, CHROMIUM, AND TITANIUM IN PEATS.[2]

BY CHARLES BASKERVILLE.

Attention has been called by Dr. W. F. Hillebrand[3] to the comparatively wide-spread occurrence of vanadium in a large number of minerals and rocks. He states that "Hayes in 1875 reported its occurrence in a great variety of rocks and ores. Quoting from Thorpe's 'Dictionary of Chemistry,' 'it is said to be diffused with titanium through all primitive granite

1 Method ascribed to Noyes was previously published by F. W. Clark in *Silliman's Journal, 1868.* (Letter to writer.)

2 Read before the North Carolina Section of the American Chemical Society at the midwinter meeting. Publ. *J. Am. Chem. Soc. 441, 706.*

3 *Am. J. Sci., 6, 209 (1898).*

rocks (Dieulafait) and has been found by Deville in bauxite, rutile, and many other minerals, and by Bechi and others in the ashes of plants and in argillaceous limestones, schists, and sands.....' It is further reported to comprise as V_2O_5 0.02–0.07 per cent. of many French clays, 0.02–0.03 per cent. of some basalts, 0.24 per cent. of a coal of unknown origin, and 0.45 per cent. of one from Peru, amounting to 38.5 per cent. and 38.0 per cent. of the ash, and noted respectively by Mourlot and Torrico y Meca."

Roussel[1] states that a basalt with a content of 0.707–2.378 per cent. of titanium contained 0.006–0.023 per cent. of vanadium. Gladstone,[2] however, states that it does not occur in the volcanic dust of Vesuvius. Terreil[3] found it in iron ores. Stolba[4] also mentions its occurrence.

From the above the presence of vanadium could with reason be suspected in peat. In the hands of the writer were samples of peats from Hyde Swamps, one mile south of Pungo Lake near the Northern Junction of Beaufort and Hyde Counties, N. C. The approximate analysis of these peats gave :

Sample.	Water.	Volatile matter.	Fixed carbon.	Ash.
Peat I.....	73.67	16.16	9.72	0.45
Peat II.....	71.58	17.42	10.31	0.69
Peat III.....	76.01	14.19	9.32	0.48

The water was determined by taking a cube measuring about eight cm. each way (from 700 to 800 grams) and bringing to a constant weight by heating for a number of hours not higher than 105 C. An analysis, approximate, of this dried peat gave the following results:

Sample.	Volatile matter.	Fixed carbon.	Ash.
Peat I.....	61.38	36.90	1.72
Peat II.....	61.35	36.20	2.45
Peat III.....	59.13	38.85	2.02

It was convenient to examine the ash of a large number of

1 *Ber. d. chem. Ges., 6, 1417 b.*
2 *Ibid., 5, 815 b.*
3 *Ibid., 10, 731 a.*
4 *Chem. Centrbl. (1897), 121.*

peats from this and other localities to ascertain the presence of titanium. We have found no statements regarding the presence of this element in these ashes, although such a surmise was logical. Neither does chemical literature, as far as we have been able to examine, give any mention of the occurrence of chromium in peats. Appended are the results of seeking for these elements in the samples mentioned above.

Sample.	Titanic oxide.	Chromium sesquioxide.	Vanadium pentoxide. Percentages in ash.
Peat I	0.490	0.0283	0.00107
Peat II	0.340	0.0343	0.0026
Peat III	0.491	0.0355	0.0031.

In determining titanium the ash was decomposed according to the method of W. A. Noyes,[1] namely, by fusion with sodium fluoride and potassium pyrosulphate. The melt was brought into solution with Dunnington's[2] necessary precaution in mind: *viz.*, having from five to ten per cent. of sulphuric acid present. Hydrogen dioxide was added according to Weller's[3] well-known method and the titanium determined colorimetrically. All hydrofluoric acid was driven off in the fusion and the hydrogen dioxide was free from that acid as well. Hillebrand[4] has shown the necessity for this.

Chromium[5] and vanadium[6] were estimated according to the latest method of Hillebrand.

A STUDY OF CERTAIN DOUBLE CHROMATES.

BY W. G. HAYWOOD.

Zehenter has stated (Monatshefte f. chemie 18. 48–55 Cen-

[1] *J. Anal. Appl. Chem.*, *5*, *39*.
[2] *J. Am. Chem. Soc.*, *13*, *210*.
[3] *Ber. d chem. Ges.*, *15*, *2592*.
[4] *J. Am. Chem. Soc.*, *17*, *718*; *Chem. News*, *72*, *158*.
[5] *J. Am. Chem. Soc.*, *20*, *454*.
[6] *Ibid.*, *20*, *461*; *Am. J. Sci.*, *6*, *209*.

tral Blatt. 97.I.857) that when a boiling solution of potassium bichromate is neutralized with sodium carbonate according to this equation,

$$K_2Cr_2O_7 + Na_2Co_3 = K_2CrO_4 + Na_2CrO_4 + CO_2 ;$$

then concentrated over the direct flame and over sulphuric acid, first the double salt $3K_2CrO_4.Na_2CrO_4$ will crystallize out in the form of flat or column-shaped crystals, then a salt of the same composition with one half molecule of water and finally yellow crystals of the salt $Na_2CrO_4.4H_2O$. The sodium chromate prepared by Johnson which crystallized with ten volumes of water was not obtained. Zehenter also prepared the salts $3K_2CrO_4.2(NH_4)_2CrO_4$ and $NaNH_4CrO_4.2H_2O$ by precipitation with alcohol from the appropriate solutions.

For my experiments the following solutions were prepared :

1. 100 grams of potassium bichromate were dissolved in water and neutralized with sodium carbonate.

2. 100 grams of sodium bichromate were dissolved in water and neutralized with potassium carbonate.

3. 100 grams of ammonium bichromate were dissolved in water and neutralized with sodium carbonate.

4. 100 grams of sodium bichromate were dissolved in water and neutralized with ammonium carbonate.

5. 200 grams of potassium bichromate were dissolved and neutralized with sodium carbonate (repeating No. 1).

6. 110 grams of potassium bichromate and 98 grams of sodium bichromate were dissolved in hot water and evaporated.

7. 67 grams of potassium chromate and 60 grams of potassium carbonate were dissolved and evaporated.

8. 100 grams of potassium bicarbonate were dissolved and neutralized with magnesium carbonate.

9. 100 grams of potassium chromate and 55 grams of sodium carbonate were dissolved in hot water.

All of these solutions were concentrated and then placed over sulphuric acid for crystalization. The crops of crystals were carefully separated, washed, dried between filter paper and analyzed.

In the case of this solution (1) the crystals which first formed were found to contain a good deal of carbon dioxide. It was evident that the solution had not been exactly neutralized by the sodium carbonate but that an excess had been used. With successive crops the amount of carbon dioxide decreased and of chromium increased. Although the analysis of the third and fourth crops approached nearly to that of the double chromate reported by Zehenter, traces of carbon doxide were found throughout, and so another solution was prepared and more carefully neutralized. But the evident crystallizing together of the chromate and carbonate raised the question as to the possible formation of a body of exact composition containing these two. In the case of solution (1) the first crop of crystals was practically all chromate and the seventh and later crops again strongly carbonate. In solution (7) when potassium chromate and potassium carbonate were mixed several crops of crystals were gotten, the first being almost pure chromate and the latter carbonate, the two showing little tendency to crystallize together.

In solution (2) the 3rd crop of crystals gave 27.45 percent. Cr.; 4th crop, 28.10; 5th crop, 27:15; 6th crop, 28.03. There was a failure in this case also to prepare crystals of definite composition.

From solution (3) three crops of very deliquescent brown crystals were gotten which corresponded in composition to the formulas $2Na_2CrO_4.(NH_4)_2CrO_4.4H_2O$.

From solution (4) crop (a) seemed to be a mixture, yielding nothing definite; crop (b) consisted of crystals of $NaNH_4CrO_4.2H_2O$; crops (c) and (d) gave sodium chromate, $Na_2CrO_4,4H_2O$, differing from the ordinary chromate with ten molecules of water.

Solution (5) yielded first potassium bichromate and then a large number of crops of large flat hexagonal crystals which had the composition $3K_2CrO_4.Na_2CrO_4$

Solution (6) yielded no new compound, the two bichromates crystallizing out separately.

Solution (8) yielded a large number of crops of the double chromate of potassium and magnesium $K_2CrO_4.MgCrO_4.2H_2O$.

Solution (9) gave crystals of carbonate containing no chromium and also crystals of the salt $3K_2CrO_4.Na_2CrO_4$.

This work in the main confirms that of Zehenter though it introduces some new modes of formation of the double salts. It gave rise to some interesting questions though the time was too brief to answer them.

ORIGIN OF PALEOTROCHIS.[1]

BY J. S. DILLER.

Prof. Ebenezer Emmons,[2] while State Geologist of North Carolina, discovered among the so-called Taconic rocks of Montgomery County, in that State, a number of more or less regularly striated bi-conical forms to which he gave the names Paleotrochis major and minor, and regarded them as siliceous corals as well as the oldest representatives of animal life upon the globe. According to Emmons, Paleotrochis varies in size up to two inches in diameter, and occurs with many almond shaped concretions, often within concretions, in a series of beds over 1,000 feet in thickness interstratified with beds of granular quartz, conglomerate and quartzite.

[1] This paper is reprinted here from the American Journal of Science (May, 1899, page 337) as a substitute for an article which the present writer had intended publishing, setting forth the same general data and conclusions. Mr. Diller's work has removed all doubt as to the mineral origin of Paleotrochis; and the republication of his paper in the Mitchell Journal is considered advisable owing to the intimate association of the Paleotrochis with local North Carolina geology, and the previous publication in this journal of Mr. White's paper (see note below) which argued in favor of the organic origin of this interesting form.

[2] Geological Report of the Midland Counties of North Carolina, 1856, page 62; also Am. Jour. Sci., II, vol. xxii, page 390, and vol. xxiv, page 151.

Both species of Paleotrochis have the form of "a flattish double cone applied base to base" with the surfaces grooved somewhat irregularly from near the apex to the basal edge. The smaller form, P. minor, has the "apex of the inferior side excavated or provided with a small roundish cavity" and the other apex "supplied with a small rounded knob, from the base of which the radiated grooves begin." The larger form, P. major, "differs from the foregoing (P. minor) in the absence of the roundish apical depression of the lower side and the knob of the opposite side."

Prof. Emmons regarded Paleotrochis not only as originally siliceous but also gemmiferous, thus accounting for knobs as well as irregular adhering groups, and it is important to note that he reports "these fossils also occur in a variety of quartz or quartzite which I have described as a buhrstone, and which is often porphyrized."

Prof. James Hall,[1] after an examination of many specimens, regarded the Paleotrochis of Emmons as nothing but concretions in quartz rock. Prof. O. C. Marsh[2] examined the forms microscopically and found them composed of fine-grained quartz, but no trace of organic structure could be detected. While maintaining its inorganic nature he regarded it as difficult to explain, and considered it as having some analogy with cone-in-cone, which he thinks is probably due to the action of pressure on concretionary structure when forming.

The most extensive paper on this preplexing form is that of Mr. C. H. White,[3] who strongly advocates the organic nature of Paleotrochis. The specimens he examined were those obtained by Prof. Emmons, as well as a number collected by Prof. J. A. Holmes, the present State Geologist of North Carolina. Mr. White describes in detail not only the peculiarities of the weathered surface of the rock but also the features exhibited upon a fresh fracture, and called attention

[1] Am. Jour. Sci., II, vol. xxiii, page 278.

[2] Am. Jour. Sci., II, vol. xlv, page 218.

[3] This Journal 1894. Pt. 2, 50–66.

for the first time to the radial fibrous mineral which he regarded as impure chalcedony. According to Mr. White, the fossil forms are enveloped in chalcedony and the small concretions are made of the same material.

In 1887, Prof. J. A. Holmes[1] visited the Sam Christian Gold Mine of Montgomery County, N. C., and studied the Paleotrochis-bearing rock in the field. Although he had not then seen any of the acid volcanic rocks from New England, described by Dr. M. E. Wadsworth, or from the South Mountain region of Maryland and Pennsylvania, subsequently described by Dr. G. H. Williams and Miss Florence Bascom, he was of the opinion that the rocks in the neighborhood of the Sam Christian Gold Mine were of eruptive origin. Later observations have convinced him of the correctness of this view. The same opinion is entertained by Messrs. H. B. C. Nitze and George B. Hanna,[2] who consider the Paleotrochis-bearing rocks at the Sam Christian and Moratock Mines as ancient acid volcanics, and state that "it appears highly probable that at least some of these siliceous pebbly concretions are spherulites." Unfortunately in the preparation of their report time did not permit the authors to study thin sections.

The specimens which, at the request of Mr. C. D. Walcott, the Director of the U. S. Geological Survey, the present writer has had an opportuntity to study, consist of a small collection[3] from Mexico sent by Prof. H. S. Williams, besides three fragments about nine inches in diameter sent by Prof. J. A. Holmes, who collected them in 1887 at the Sam Christian Gold Mine, North Carolina, and from the same place several dozen of the original specimens of Paleotrochis major and minor collected by Prof. Emmons. Specimens of the rock and isolated fossils, excepting those from Mexico, have been cut and polished and thin sections prepared for microscopical study.

The rock from North Carolina which contains Paleotrochis

1 Letter to the author Feb. 6, 1899.

2 North Carolina Geological Survey, Bul. No. 3, pages 37 and 39.

3 See Prof. Williams' article, *Am. J. Sci.*, *335*, 1899.

is full of nodules of various shapes and sizes, ranging from that of a pin's head to nearly two inches in diameter. These are the supposed concretions and fossils. Upon a fresh fracture the rock appears to be composed chiefly of quartz, but when weathered most of the nodules become white as if kaolinized, while the other nodules and the matrix remain quartzose in appearance. The nodules form at least two-thirds of the mass of the rock and are arranged with their longer diameters parallel, rendering the rock rather easily split in one direction.

With a lens, it may be seen that the small kaolinized nodules exposed in section upon the surface of a hand specimen have a radial fibrous structure. The same structure may be seen in some of the larger ones, and in addition to this feature some of the nodules possess a more or less distinct concentric shell-like structure. These structures are usually best displayed upon or close to a weathered surface. Portions of the nodules or spaces between them are in a few cases cellular, and the walls of the openings are rarely lined with minute crystals. The supposed fossil forms usually appear conical or discoidal upon a weathered surface. They often show a small cup in the apex and are surrounded by a narrow depression from which the radial fibrous envelope, pointed out by Mr. White, has been removed by weathering.

A careful comparative study of the nodules in the hand specimens tends to convince one that however different in form and size the supposed fossils and concretions may appear, all belong to one series and have essentially the same origin.

A microscopical study of thin sections of the rock reveals the fact that the nodules are spherulites, a common feature of acid igneous rocks. They are composed in most cases chiefly of fibrous feldspar with quartz or tridymite. As seen in the thin section of the Paleotrochis-bearing rock, the fibres are grouped radially with more or less irregularity in tufts, sheaves, sectors, hemispheres or spheres. When they form a complete sphere, which is rarely the case, they are most

coarsely fibrous or granophytic at the center and usually show between cross nicols an indefinite black cross. Occasionally also the concentric structure is well marked. The rays are too minute to permit of an accurate determination of their mineral composition by optical methods, but microchemical tests with hydrofluosilicic acid yield the small cubic crystals, characteristic of potassium fluosilicate as well as the hexagonal prisms of sodium fluosilicate. Judging from the greater abundance of prisms than cubes the fibrous feldspar is richer in sodium than potassium. That feldspar, instead of chalcedony, is the most prominent constituent of the spherulites, is fully borne out also by its kaolinizing under the influence of the weather.

The spherulites are embedded in a matrix composed chiefly of granular quartz. The grains are occasionally so large that the uniaxial positive character can be readily determined. Untwinned feldspar in small grains may be present in considerable amount but yet be easily overlooked. The quartzose character of the weathered matrix, however, shows that at least where most coarsely granular there cannot be much if any feldspar present in it. In places the matrix contains numerous minute parallel scales of what appears to be sericite. Associated with the most coarsely crystalline areas are a few scales of brown biotite and occasionally considerable green biotite, which in places is so abundant as to make quite prominent dark green spots. Both matrix and spherulites are traversed in a few cases by small veins of granular quartz, showing that there is a considerable amount of secondary quartz present. Both spherulites and matrix are rendered slightly microporphyritic by containing occasional crystals of plagioclase feldspar and quartz. The plagioclase, which, on account of its small angle of symmetric extinction, must be an acid one, in some cases forms the center from which the spherulitic fibres radiate.

An isolated specimen of Paleotrochis was cut through the apices and found to be composed of granular quartz. The quartz was fine-grained upon the outside where the grains

were set with their longest axes perpendicular to the adjoining surface. The middle portion contained an irregular iron-stained cavity possibly due to the disappearance of some iron-bearing mineral. Several of the half embedded forms of Paleotrochis were cut in a hand specimen to discover its relations to the enclosing rock, and in each case it formed the interior portion of a spherulite. Most of them contained a dark green patch. The exposed conical surface of one was well striated and there was an irregular depression in the apex. The form was composed chiefly of granular quartz with a yellowish brown to dark green, strongly pleochroic, biotite. Near the center is a small spherulite which is not only bordered by finer-grained quartz but is cut by a small vein of it, showing that the deposition of the quartz is subsequent to the development of the spherulite. The embedded portion of Paleotrochis is bordered by spherulitic fibres which run approximately parallel to the slope of the conical surface, and it is evident that the casts of these fibers produce the irregular striæ or grooves upon the surface of the supposed fossil. The embedded portion terminated with an irregularly-pointed apex below. The whole form is fine-grained near the border and sends small veins into the adjoining spherulitic shell. These veins are so small as not to be visible upon a polished surface of a hand specimen even with the aid of a pocket lens, but come out distinctly in the thin section. The spherulitic shell by which Paleotrochis is enveloped is composed of fibers belonging to a number of centers or lines and yet combined they appear to form one nodule. The biconical form of Paleotrochis suggests that it originated as two spherulite sectors of which the apices were the centers from which the fibres radiated. This would seem to be the simplest way to account for the most regular as well as many of the irregular forms, but of the specimens examined I have not been able to find one that certainly originated in that way.

A number of the fossil forms with a well-marked cup in the exposed apex turned out to be flat hemispherical or thin lenticular in section, and are composed wholly of spherulitic fibers.

Although admitting much irregularity, especially on account of the supposed gemmiferous character of Paleotrochis, the ones which have been considered the most characteristic of the fossil are the distinctly biconical forms. These, so far as seen, are chiefly granular quartz with more or less green biotite.

It is important to note also that the dark groups of green biotite occur in the interior of very irregular nodules which have no suggestion in them of Paleotrochis. Irregular flattened lenticular masses of granular quartz with green biotite occur within the spherulites as well as about them. The green mica is found only in the most coarsely granular groups of quartz.

The following chemical analysis, made by W, F. Hillebrand, shows that the rock has the composition of a rhyolite and accords closely with the results of the microscopical study.

Analysis of the Paleotrochis-bearing rock of Sam Christian Mine.[1]

SiO_2	79·57	
TiO_2	·11	
Al_2O_3	11.41	with a very little P_2O_5
Fe_2O_3	·20	
FeO	·70	
MnO	none	
CaO, SrO	·21	
BaO	.50	
MgO	a very little	
K_2O	3·52	
Na_2O	3·46	
H_2O below 105°	·18	
" above "	·61	(ignition)
	100·02	

Recognizing the Paleotrochis rock as an acid volcanic, full of spherulites, it is easy to understand the great variation in

[1] No other constituents looked for.

the form of the nodules. Such rocks are in many places distinctly banded and were long considered siliceous sediments, but by the investigations of Wadsworth, Williams, Bascom and others it has been definitely settled that they are all acid volcanics. These rocks in North Carolina are regarded by Mr. Holmes as pre-Cambrian and since their eruption may have undergone great changes like those of the South Mountain described by Miss Bascom. Some of the supposed fossils are certainly spherulites, and all of them may have been originally. Some broken forms show motion in the mass after the spherulites were developed. That Paleotrochis, where most perfectly developed and composed of granular quartz, is the result of deposition, after the spherulitic growths about it and within it had developed, there can be no question, but whether this deposition followed soon after that of the spherliutes in the course of solidification or took place in hollow spherulites (lithophysæ), or resulted perhaps long subsequently at the time of rock alterations, is not so clear. All this and much more will doubtless be cleared up by the members of the Geological Survey of North Carolina, who were the first to correctly identify the rock and the character of the supposed fossil.

None of the Mexican specimens received from Prof. Williams were cut for microscopical examination. Some of them were clearly of igneous origin, and contained amygdules. The Paleotrochis-like forms with radial markings appeared to be composed of secondary quartz and probably originated as those of North Carolina.

About a year ago bi-conical forms like Paleotrochis were presented by Mr. Kochibi, Director of the of the Geological Survey of Japan to the U. S. Geological Survey. These specimens are now in the National Museum, and are much more regular in form, size, and general appearance than the Paleothrochis of North Carolina. They are of a pale pink color with regular bi-conical, striated forms, and in some cases have shallow pits of the apices. They are known in Japan as "*Sorobanishi*" or abacus stones. One of these specimens con-

tains a small fragment of the rock from which these curious specimens were obtained, and it appears to be spherulitic. According to Mr. Willis, who obtained the information directly from Mr. Kochibi, "these stones are found only in rhyolitic tufts. They not infrequently occur much larger than these specimens, possibly up to two inches in diameter or more, and are more frequently associated in groups of two or three overlapping or coalescing. They are generally white, the rosy tint of these specimens being a rare characteristic." A thin section of one of these "abacus-stones" shows it to be an agate of which the outer layers are pink and the inner white. There can be no doubt in this case that the form resulted from the filling of the cavity long after the solidification of the igneous material.

THE DEEP WELL AT WILMINGTON, N. C.[1]

BY J. A. HOLMES.

The deep well which is now being bored at Wilmington, N. C., is of especial interest to geologists: (1) That in reaching granite, as it does at about 1109 feet, it shows the absence at this point of the formation between the upper Cretaceous and the old crystalline floor underlying the coastal plain deposits; (2) it shows the existence there of an unfortunately and unusually thick series of salt-water-bearing strata, from 350 to 1100 feet below the surface; (3) it may throw some light on the relations between the deposits of the sand hill regions (generally classed as Potomac) and the upper Cretaceous beds penetrated by this well.

The well is located on the bank of the northeast Cape Fear

[1] *Science*, N. S. XI., 265, Jan. 26, 1900, p. 128.

River, at Hilton Park, one mile north of Wilmington. The river border at this point exhibits two terraces; one only a few feet above tide water, extending back a distance of 30 or more feet from the river; and the other rising 30 to 40 feet higher, extending back for a considerable distance, and indeed representing the general surface of the region. The difference in elevation between these two terraces represents the thickness of the remnants of the Tertiary fossiliferous clays and limestone and the overlying recent sands. The lower terrace represents the upper surface of the Cretaceous; so that the well starts in the Cretaceous clays and sands, and continues in them to a depth of some 1109 feet. In these sands and clays there are occasional beds of shell-rock and calcareous sandstone, varying in thickness from a few inches to 30 feet, and occasional thin beds of clay containing small nodules or concretions. The sands are mostly micaceous and are usually quite fine grained, with a prevailing gray color. From about 700 to 800 feet, their color is decidedly greenish. Below 950 feet these sands become coarser and are interbedded with occasional gravel deposits, but they continue fossiliferous to near the surface of the granite.

Waterbearing sands and gravels were penetrated at a number of points, notably at 380, 496, 520 and 574 feet; and at 1011 the largest flow, of nearly 400 gallons per minute, was encountered, with pressure estimated as sufficient to raise the column of water 80 feet above the surface. Unfortunately the water from each of these levels was highly brackish, and hence unfit for domestic use.

The fossil forms secured at different depths have been identified by Dr. T. W. Stanton, of the United States Geological Survey. The method used in sinking the well is the ordinary drill and sand pump; and, as might be expected, in some cases only fragments of shells were secured; but as the hole was of large diameter (12 inches near the surface, then 10 inches, and lower still, 8 inches) and the larger part of the matrix material quite soft, a minimum amount of drilling was needed; and many large fragments and many perfect forms were obtained.

Among the fossils secured from the upper 700 feet, classed as Ripley cretaceous, the following may be mentioned:

Cardium enfaulense Gabb, was found at 40 feet and 538–558 feet, and fragments of this or another Cardium were found also at 50, 485–490, 520–540 and 556–575 feet below the surface.

Anomia argentaria Morton, was also common, having been obtained at frequent intervals from 40 to 600 feet; and fragments of an *anomia*, too small for specific classification, were also found 800 to 900 feet below the surface.

Exogyra costata Say, was abundant throughout the upper half of the section; and below 500 feet a varietal form of this species, approaching *Exogyra ponderosa* Roemer, in surface feature, was found almost to the granite.

Ostrea tecticosta Gabb, was common from 230 to 650 feet; and *O. larva* Lamarck, from 250 to 330 feet; and fragments secured at 518 feet probably belonged to one of these species. *O. subspatulata* Lyell & Forbes, was found only between 332 and 380 feet. Throughout the entire section, however, were found numerous fragments of *Ostrea* too imperfect to serve for specific determinations. *Veleda lintea* Conrad, and *Aphrodina tippana* Conrad (?) were found only at 340 to 500 feet. *Baroda Carolinensis* Conrad, and *Cyprimeria depressa* Conrad, were found only between 332 and 380 feet; and fragments of *Pecten* were found at 40 to 50 feet.

Gryphaea vesicularis Lamarck, was found at 250 to 265, and 720 to 735 feet (?); and *Inoceramus cripsii* Mantell, at 575 to 585 feet and probably also at 500 to 518 feet. Unrecognized species of *Avicula* or *Gervilia* were obtained at 390 to 400 feet; *Corbula* at 492; *Pectunculus* 520 to 540 feet, and *Lunatia* 520 to 590 feet; *Lithophagus* 540 to 560 feet.

Cassidulus subquadratus Conrad, was observed at 518 to 538 feet, and echinoid spines and fragments of the same or allied species were also found at 100 to 170 feet. Sharks' teeth, fish vertebræ, fragments of turtle shell, lignite and pyrite were found at intervals in the section.

Below 720 feet, and down to the granite (1109) *Ostrea cre-*

tacea Morton, which in the Chattahoochee river section is confined to the Eutaw beds, is here quite common ; and is accompanied at intervals by *Anomia Exogyra*, *Cardium* and *Serpula*, the specimens collected being in each case too fragmental to permit of specific determination. This lower 400 feet of the Wilmington section has been classed by Stanton as *Eutaw* ; and it is possibly the seaward representative of the Potomac arkose sands and clays of the sand-hill region northwest of Fayetteville, should these sands and clays prove to represent the latest Potomac. It is more likely, however, either that the Potomac deposits were removed from this region prior to the Eutaw deposition, or else that the surface of these old crystalline rocks was above water level during Potomac time, and hence not covered with deposits.

Underground temperatures were not taken at intervals at different depths while the work was in progress, owing to the lack of suitable thermometers ; but there are now three wells only three or four feet apart, one 1100, one 500 and one 100 feet deep. The temperatures at the bottom of each of these, as determined by the use of a Darton deep well thermometer, were found to be 79°, 72.50°, and 68.50°F. respectively, giving a descending increase in temperature of about 1°F. for each 100 feet, between 100 and 500 below the surface ; and 1°F. for each 98 feet, between 500 feet and 1100 feet below the surface.

CHAPEL HILL, N. C.

NEW EAST AMERICAN SPECIES OF CRATAEGUS.

[1] CONTRIBUTIONS FROM MY HERBARIUM. NO. VI.

BY W. W. ASHE.

Crataegus perlomentosa n. sp. A small tree, 4–9 meters in height, with horizontal branches forming a round or flattened crown, trunk covered with gray bark broken into oblong

[1] Received Feb. 10, 1900.

scales, and often armed with long, gray or dark purple thorns: branches gray, armed with numerous 6–9 cm. long, dark red-brown purplish or nearly black, straight or slightly curved thorns: twig of the season glabrous brownish-red or brown: buds globular, red-brown, glabrous. Leaves broadly ovate or nearly orbicular, obtusely pointed at the apex, broadly cuneate, rounded or even subcordate at base, the blades 4–6 cm. long, 3–5 cm. wide with 5–7 pairs of prominent veins, acutely glandular serrate, doubly serrate or with 3–5 pairs of shallow lobes above, entire at the base, thick, subcoriaceous, dark green, glabrous and lucid above, paler and soft or roughish pubescent beneath: petiole 5–10 mm. long, margined above. The flowers are borne in 4–10-flowered compound tomentose corymbs, the lower branches from the upper leaves: fruiting pedicels strict, 2–4 cm. long pubescent: styles 3–4; stamens 10–15: calyx pubescent, its acute divisions entire or glandular laciniate. Fruit glabrous 8–13 mm. in diameter, red or yellowish: flesh thick: nutlets 3–4 with shallow furrows on the back.

This tree is related to *Crataegus tomentosa L.* from which it is separated by having smaller, broader and more pubescent leaves, fewer stamens and fewer-flowered corymbs. Type locality: Johnson county, Kansas, where I collected it last year. The type material is preserved in my herbarium.

Crataegus neo-fluvialis n. sp. A small tree 3–5 meters in height with long horizontal branches forming a flattened crown: branches gray, nearly straight or flexuous, armed with numerous slender, red-brown purplish or grayish, straight or slightly curved, 4–7 cm. long thorns: twig of the season red-brown, glabrous, marked with few pale ovate lenticels: winter-buds prominent, subglobose, red-brown, glabrous. Leaves lucid, dark green and nearly glabrous above, scarcely paler and pubescent to glabrate beneath, the pubescence soft and abundant on unfolding, becoming scanty and roughish with age, the blades elliptic or rhombic ovate in outline, 5–10 cm. long including the petiole, acute and entire towards the base which gradually narrows into the mar-

gined petiole, acute at the apex, finely and sharply glandular serrate, above the middle doubly serrate or with 2–3 pairs of shallow lateral lobes, 5–7 pairs of prominent straight parallel deeply impressed veins: petiole short, margined, glandless, 5–15 mm. long. The flowers are in large, 8–15-flowered, nearly glabrous, compound corymbs, the lower branches from the axils of the upper leaves: pedicels strict, 5-20 mm. long; stamens 10–15, longer than the 3–5 styles: divisions of the calyx lanceolate, 5 mm. long, sharply glandular serrate or entire. Fruit 6–9 mm. in diameter, nearly round, greenish, orange or rosy-cheeked, flesh thin and firm: seed 3-5, smooth or slightly ridged on the back, 4–5 mm. long, 3–4 mm. thick dorso-ventrally, the lateral faces concave.

Crataegus neo-fluvialis is related to *Crataegus macracantha Lodd.*, from which it is separated by having narrower acute pubescent leaves, and somewhat smaller fruit which lacks the bright red so characteristic of *Crataegus macracantha Lodd.* It is frequent along the North Fork of the New River in Ashe county, North Carolina, and the adjacent part of Virginia. The type material is preserved in my herbarium.

Crataegus Margaretta n. sp. A small tree 4–5 meters in height with rather short horizontal or ascending branches forming an open oval crown, or sometimes a large shrub: branches gray, flexuous or geniculate, unarmed thornless or sparingly beset with short, 2–3 cm. long, slender red-brown thorns, twig of the season geniculate, red-brown, glabrous, marked with numerous, very small gray lenticels: winter-buds subglobose, rather large, the few glabrous scales red-brown. Leaves glandless, glabrous, or at first with a few short hairs on the upper surface, membranaceous, or at length firmer, bright green on both sides, the blades broadly rhombic to nearly orbicular, or even broader than long, 3–5 cm. long, 2.5–6 cm. wide, with 3–6, generally 5 pairs of prominent straight veins, obtusely serrate and with 3-5 pairs of generally shallow lobes above the middle, or deeply lobed on vigorous shoots, obtusely or acutely pointed at the apex, entire or distantly serrate towards the obtuse or broadly wedge-

shaped base: petiole slender, 15–25 mm. long, narrowly winged above. The flowers which appear when the leaves are almost full grown in 7–12-flowered nearly simple corymbs, the lower branches from the axils of upper leaves, are white, 12–15 mm. wide and borne on strict glabrous pedicels 10–22 mm. long: petals orbicular, with a short claw, calyx glabrous, its divisions entire or sparingly serrate: styles 2–3 in number, 5 mm. long overtopping the 15–20 glabrous stamens: bractlets of corymbs and stipules of unfolding twig early deciduous, greenish, not conspicuously colored, spathulate, pectinately glandular. Fruit quite 1 cm. in diameter, nearly round, glabrous, fleshy, reddish or orange, persistent until late in the winter, on strict, slender pedicels: nutlets usually three, about 5 mm. long, the broad convex back deeply grooved and ridged. In eastern Missouri the flowers appear about the middle of May.

Crataegus Margaretta is found from eastern Iowa and southern Illinois to eastern Missouri, generally occurring along small streams. It is apparently related to *Crataegus punctata Jacq.*, from which it is distinguished by having fewer-flowered leafy corymbs, smaller fruit, and much broader leaves, which are pointed and have fewer pairs of prominent veins. The type material is preserved in my herbarium. The type locality St. Louis county, Mo.

Crataegus macrosperma n. sp. A small tree 5–7 meters in height, with wide-spreading branches, forming an oval or round crown, the trunk covered with gray-brown bark broken into small oblong scales: branches gray, armed with numerous short, very stout, 1–3 cm. long, dark red-brown or purplish to nearly black thorns: twig of the season rather thick, dark red-brown to purplish, sparingly glaucous glabrous, marked with a few small grayish lenticels. winter-buds rather large, oval or globular, dark red-brown, the obtuse or rounded scales glabrous. Leaves membranaceous but firm, dark green above, paler and sparingly glaucous or whitish beneath, the blades deltoid or broadly oval, obtuse at the apex, rounded, subcordate or on vigorous shoots cordate with a narrow sinus

at the base, varying greatly in size even on the same twig, 3–6 cm. long, 2–5 cm. wide, finely but sharply serrate to the base, doubly serrate or with 3–5 pairs of shallow lobes above, the serratures acutely gland-tipped, 4–6 pairs of prominent veins: petiole 1–2 cm. long, generally short and less than one-third the length of the blade, channeled, narrowly margined, at least above, and with a few glands near the base of the leaf. The flowers, which appear when the leaves are nearly grown in few 4–9–flowered nearly simple corymbs, are white 14–17 mm. wide and borne on slender pedicels: calyx glabrous, its divisions lanceolate, short, 3–5 mm. long, persistent and coloring with the fruit: styles 3–4: stamens 5–10, generally 5, the base of the very stout filaments persistent and coloring with the fruit. The fruit 13–18 mm. in diameter, borne in small clusters, is somewhat longer than thick, a uniform dark but bright red when ripe, glabrous and sometimes sparingly glaucous, flesh thick and mealy, pedicels strict and very slender generally falling with the fruit, which falls from the tree during the latter half of September: nutlets 3–5, deeply grooved and ridged on the back, 5–7 mm. long, 5 mm. thick dorso-ventrally, the lateral faces plane.

Crataegus macrosperma is found in northern Alabama and northwestern Georgia and the adjacent portions of Tennessee, growing frequently along rocky, especially cherty ridges in open woods, or often on exposed and thin-soiled almost untimbered rocks. It is frequent on Lookout Mountain, Tenn., which is the type locality, and where it was first collected by me in 1897, and on the surrounding mountains. This species is related to *Crataegus coccinea L.*, or more closely to *C. silvicola Bead.*, from which it is separated by having shorter stouter spines, smaller leaves, and much larger fruit. The type material is preserved in my herbarium.

Crataegus coccinioides n. sp. A small tree 4–6 meters in height with numerous spreading or ascending branches forming a round or oval crown: the gray bark of the trunk broken into small scales, often armed with long simple or compound

thorns: branches flexuous, dark gray, armed with numerous dark red or nearly black thorns, 2.5–5 cm. long: twig of the season glabrous, dark purple-brown, marked with a few pale, nearly orbicular lenticels: winter-buds small nearly globular, dark red, glabrous. Leaves glabrous, membranaceous, rather lax bright green above, scarcely paler beneath, the blades ovate, broadly oval or even isodimetric, 4.5–7 cm. long, 4–6.5 cm. wide, acute or obtuse at the apex, truncate, subcordate or on vigorous shoots cordate at the base with a broad open sinus, sharply and irregularly glandular serrate, above doubly serrate or with 3–4 pairs of shallow lateral lobes, entire towards the base, 4–6 pairs of prominent veins: petiole slender, terete, 2–6 cm. long, generally two-thirds the length of the blades, sometimes slightly margined and with a few glands near the base of the leaf. The flowers which expand when the leaves are scarcely half grown in small 5–8–flowered corymbs, are white, 18–20 mm. wide, and on slender 2–3–bracted pedicels: petals obovate 8–10 mm. long: styles 3–4, hairy at the base, shorter than the 20 stamens: calyx glabrous or minutely pubescent, its short divisions glandular serrate or laciniate. The fruit is 8–11 mm. thick, somewhat longer, bright red when mature and persistent until late in winter: nutlets 3–4, 5–6 mm. long, about 4 mm. thick dorso-ventrally, deeply sulcate and ridged on the back. Bracts and stipules lanceolate (lunate on vigorous shoots) glandular, bright colored, persistent until the flowers expand.

Crataegus coccinioides occurs along streams and in moist upland woods from southern Illinois to eastern Missouri. It is separated from the scarlet thorn by having larger leaves on longer petioles and larger fewer flowers. The type material is preserved in my herbarium.

Crataegus collicola n. sp. A small tree 5–8 meters in height with numerous wide-spreading or horizontal branches forming an oval or flattened crown, the gray bark of the trunk broken into flat, oblong scales and occasionally armed with long simple, gray thorns: the nearly straight gray branches armed with numerous, slender, gray or purple-brown, 4–8 cm. long

thorns : twig of the season glabrous, slender, dark brown-purple or gray, marked with few small pale indistinct lenticels : buds small, subglobular, brownish red. Leaves glabrous, at least when mature, firm, the larger ones becoming subcoriaceous, dark green above, somewhat paler beneath, the blades 4–6 cm. long, 2–4 cm. wide, oval and acute at the apex, or obovate and even spathulate and obtuse or rounded at the apex, tapering at the base into a short 5--15 mm. long, glandular margined petiole, or the larger leaves on vigorous shoots nearly orbicular, and abruptly contracted at the base, sharply and irregularly serrate to near the base or the larger leaves doubly serrate, or with 2–3 pairs of shallow lobes, 4–6 pairs of prominent veins : petiole broadly margined, at least above, 5–15 mm. long. The white flowers are borne in numerous, 6–14-flowered, compound, glabrous corymbs : divisions of the calyx lanceolate, acute, entire : styles 4–5. The abundant orange-red or dull red fruit is depressed globose, 8–11 mm. thick, about 8 mm. high : fruiting pedicels strict, 1–2 cm. long : nutlets 4–5, 5–6 mm. long, 3–4 mm. thick dorso-ventrally, slightly grooved on the back, the lateral faces nearly plane.

Crataegus collicola is related to the cockspur thorn from which, and all varieties of it, it is at once separated by having much broader often pointed and lobed leaves and much longer petioles. I collected this tree in the mountains of North Carolina in September, 1897 in Henderson county and near Asheville where it is found in fields and pastures on dry hillsides. The type material is preserved in my herbarium.

Crataegus Illinoiensis n. sp. A small tree with an oblong or irregular crown, or a tall shrub with virgate branches. Branches grayish-red or brownish, armed with 3–5 cm. long red-brown thorns. Twigs glabrous bright red-brown, as are the spherical buds. Leaf-blades 5–8 cm. long 4–8 cm. wide, nearly obicular or slightly obovate and broadly wedge-shaped at the base, obtuse or rounded at the apex, very sharply and glandular doubly serrate, or somewhat 3–7–lobed above, 4–6 pairs of prominent veins, minutely appressed pubescent above, pubescent beneath with rather harsh, short spreading

hairs: petioles .5–1.5 cm. long, margined above, deeply channeled. The inflorescence is in loose, 7–18–flowered, compound corymbs, the branches 1–3–flowered, the lower from the axils of the upper leaves. The flowers, appearing the latter part of May when the leaves are nearly full grown, are white, 1.5–1.7 cm. wide: petals nearly orbicular, abruptly contracted into a short claw: stamens 7–10, the glabrous filiments 7–8 mm. long, enlarged at the base, one third longer than the 3 stout glabrous styles: calyx tube obconic, 4--6 mm. long, pubescent with spreading hairs, the lanceolate divisions deeply laciuate, appressed pubescent, the serratures gland-tipped: pedicels pubescent, stout, .3--2 cm. long: bracts linear, small, inconspicuous, early deciduous. The fruit, persisting until late in winter, is 8--11 mm. thick, bright red, nearly glabrous, the flesh rather thin and firm: seed 2--4, about 4 mm. long, somewhat grooved and ridged on the back, the lateral faces plane.

This species is related to *C. Biltmoreana Bead.* from which it is separated by having much rounder leaves, larger compound corymbs, and bright red glabrous fruit. Open woods, central Illinois. I refer here to material collected at Wady Petra, Ill., by V. H. Chase, and distributed as *C. macracantha.*

Crataegus pulcherrima n. sp. A small tree 3--4 metersp in height. Twigs very slender, 2--3 mm. thick, red-purple, glabrous. Leaf-blades 2--4.5 cm. long, oval to nearly orbicular in outline, 3--7-notched above, glandular-denticulate or distantly serrate, obtuse or acute at the entire base, membranaceous, bright green and glabrous on both sides, with 4-6 pairs of prominent veins: petiole .5--2 cm. long, very slender, winged above, roughed with 1--2 pairs of sessile glands. Flowers white, in glabrous, few-flowered, nearly simple corymbs: pedicels .7--1.5 cm. long, glabrous, strict: stamens 10, styles 4--5, calyx divisions, acute, entire, deciduous. Fruit glabrous, yellowish or reddish, 5--7 mm. thick, 6--8 mm. long: seed 4--5, 3--4 mm. long, smooth on the back and the lateral faces plane.

A very distinct species. Southwestern Georgia, and northwestern Florida. Here I refer Nos. 2568 and 2377 G. V. Nash, 1895.

Crataegus Holmesiana n. sp. A small tree 3--5 metres in height, with a rounded or flattened crown and long horizontal or spreading branches armed with numerous 3--4 cm. long straight or slightly curved thorns; or generally a large shrub. Leaves ovate, the blades 4--9 cm. long, 3--6 cm. wide, obtuse or acute at the apex, acute, obtuse or somewhat rounded at the base, coarsely and acuminately serrate all around, the teeth gland-tipped with 5--9 pairs of shallow lobes or doubly serrate, 5--7 pairs of prominent veins, glabrous on both sides or when young sparingly pubescent beneath: petioles terete, slender, 1.5--3 cm. long, generally purplish, and with a few stalked glands on it near the base of the leaf. Flowers in glabrous, nearly simple few-flowered corymbs, white, 1.5--1.7 cm. wide: petals nearly orbicular contracted at base into a short claw: calyx glabrous, the divisions glabrous, nearly entire; bracts and bractlets few, linear, glandular, not conspicuous. Fruit 8--11 mm. thick, red, glabrous, falling early, 3--5 seeded.

This species in its habit resembles *C. mollis*. It is separated from the nearly related species of the *coccinea* group by having much larger leaves with very acute serratures. Central New York.

Crataegus atrorubens n. sp. A small tree or shrub. Branches gray: twigs bright red-brown, rather slender, marked with few pale lenticels: thorns few. Leaves oval, broadly ovate, or even obovate, the blades 3--7 cm. long, 2--5 cm. wide, obtusely and rather coarsely serrate, sometimes with 3--5, shallow lobes towards the obtuse apex, or merely doubly serrate, 4--6 pairs of prominent veins, entire at the rounded or subcordate base, dark green above, slightly paler beneath, membranaceous, when young sprinkled with short appressed hairs on the upper surface, especially on the veins, and pubescent beneath in the axils of the veins, at length glabrate: petioles 1.5--3 cm. long, very slender, finely pubescent, especially on the grooved upper surface. Inflorescence a 6--14-flowered

loose compound corymb, the glabrous branches generally 3-flowered: pedicels finely pubescent, bearing 1--2 filiform glandless bractlets, the bracts of the branches very few, inconspicuous, spathulate, entire, or minutely glandular denticulate: flowers white 1.5 cm. wide: petals orbicular: calyx soft pubescent, the acute divisions entire: stamens 20, scarcely longer than the 4--5 styles. Fruit globular, 9--11 mm. thick, dark red, glabrous.

Distinguished from *C. coccinea* by having more entire leaves, and being pubescent. St. Louis County, Missouri.

Crataegus polybracteata n. sp. A shrub or small flat-topped tree with spreading branches. Twigs glabrous, armed with stout curved purple-black thorns. Leaves ovate or elliptic, the blades 3--6 cm. long, 2–4 cm. wide, glandular serrate, with 3--7 shallow lobes, or doubly serrate, acute at the apex, acute or obtuse at the entire base, glabrous on both sides: petiole slender, 1--2 cm. long, narrowly margined above. Inflorescense a 4--10-flowered nearly simple corymb, the branches and stout 1--2 cm. long pedicels glandular dotted, and pubescent with rough spreading hairs: branches and pedicels with linear, spathulate, or deeply 3 parted, .5--2 cm. long bracts, which are rough hairy, pectinately glandular, and persist until after the petals fall. Flowers white, 2--2.5 cm. wide: stamens about 15: styles 3--4: calyx pubescent with a few short, spreading hairs: the divisions 4--6 long, pubescent, glandular serrate. The dull red glabrous fruit is 8--11 mm, in diameter and is borne on strict pedicels.

This species is related to *C. rotundifolia* from which it is separated by having smaller more simple corymbs, larger flowers with hairy pedicels, and large persistent glandular bractlets. Ohio to New York. The type is preserved in my herbarium.

NOTE ON A QUALITATIVE TEST FOR TIN.[1]

BY CHARLES BASKERVILLE.

Scarcely any instructor in Qualitative Analysis has failed to have difficulty in having his students make a satisfactory separation of arsenic, antimony and tin. Either of the ordinary methods of separation of the arsenic, namely, solution of arsenic sulphide in ammonium carbonate or the solution of the mixed sulphides of tin and antimony in hot concentrated hydrochloric acid, answer very well for the arsenic. The presence of antimony in the hydrochloric acid solution is easily proven by its precipitation upon platinum in the presence of metallic zinc, subsequent solution in dilute nitric or tartaric acid, and so on. The difficulty is in proving the presence of tin. Unless most of the acid has been driven off and the solution well diluted the tin fails to be precipitated on the zinc. We have usually tested the solution directly with mercuric chloride and hydrogen sulphide for tin. These tests are not always satisfactory, more or less doubt existing in the student's mind, especially if all the antimony has not been removed.

Longstaff (*Chem. News*, *80*, *282*) suggests reversing the test given by Fresenius (Qual. Anal., 8th Edit., p. 217, trans. by Johnson) for molybdic acid. Stannous chloride produces a blue coloration with molybdic acid. He uses ammonium molybdate.

We carry out the test as follows: filter from the diluted liquid any remaining particles of zinc and add a pinch of powdered molybdic acid. A deep blue color shows the presence of tin. We have proved the presence of one part in five thousand with the very roughest conditions under which a most careless student may work. Longstaff states that with every precaution for exclusion of air it is delicate for one part in a million. The color disappears in the presence of concentrated hydrochloric acid.

The presence of arsenic, antimony and zinc compounds has

[1] Read at the Midwinter Meeting of the North Carolina Section of the American Chemical Society February 24th, 1900.

no effect on the molybdic acid. Care should be taken, however, that no small particles of zinc pass into the liquid after filtering, for the nascent hydrogen generated gives the same color reaction.

February 1900.

UNIVERSITY OF NORTH CAROLINA.

NOTE ON A CASE OF SPONTANEOUS COMBUSTION.[1]

BY CHARES BASKERVILLE.

In August 1898 a fire occurred in some of the dyed warp of one of the largest cotton mills in this State. Samples of all materials used in the dyeing and sizing of the yarn were sent the writer by the proprietors of the mill with instructions to seek the cause of the fire in detail. Fortunately, as later learned, the fire was discovered in time and extinguished, avoiding very serious consequences. Such a fire was unusual with these mill owners, the first, in fact, in the history of the mill in question, and its recurrence might prove disastrous. It was necessary to learn if some irregularity in the practice or material used could have been the cause or whether it resulted from the action of chemicals surreptitiously placed upon the yarn by some ill intentioned operative.

Their customary procedure was to dye eight warps at a time (1040 lbs.) in a dye bath of two hundred and fifty gallons of water into which have been placed for each one hundred pounds of yarn eight ounces naphthazarin L. W., five pounds sal soda, one half pound Marseilles soap and six pounds salt. The bath was gradually increased to three hundred gallons and then run off. The warps were then washed with three hundred gallons of water at 180° F. and sized.

[1] Read before Midwinter Meeting of North Carolina Section of the American Chemical Society, 1899.

For sizing each one hundred pounds of yarn nine pounds of starch and three pounds of tallow were used. The warps were run off the dyeing cylinders into sacks quite hot and stored away. At the time mentioned these warps were stored away at four oclock in the afternoon. The fire was discovered at one the next morning.

Enquiry elicited these facts; first fire; all materials had been on hand some time; same dye had been used for long time; no recent new purchase of dye; *the mill shut down for repairs immediately after the the dyeing and before the sizing of the warps which caught fire.*

Careful microscopic examination of the yarn showed only such changes in the fibre as resulted from the mechanical strain to which it had been subjected in the spinning and an even distribution of the dye. No spotted effect was observed such as would occur if chemicals in careless or ignorant hands had been placed upon the yarn intentionally or by accident.

The dye used is commercially called "naphthazarin L. W." By analysis and investigation of the patent literature it was found to be a mixture of equi-molecular parts of tetrazo-diphenyl, sodium salt of amido-naphthol disulphonic acid and dihydroxynaphthalene precipitated by and incorporating more or less sodium chloride. The tetrazo bodies under certain conditions, namely, acid, liberate oxides of nitrogen which may oxidize such substances as cotton. No acid was used according to the dyeing formula.

Fires have frequently resulted from the oxidation of fats, as when old greasy rags are packed away in a warm place for a long while. According to the ordinary method of dyeing as practiced in this mill the rapidity of the work does not give time necessary for oxidation which produces heat. In this case two weeks intervened and the tallow used in finishing either being on hand and exposed more or less to the atmosphere during a warm season permitting the oxidation to begin became rancid, or it was purchased rancid. The oxidation of the fatty constituents of tallow once begun con-

tinues with greater rapidity the better the conditions, namely heat, which conditions prevailed in this case.

The tallow used melted at 42° C. Normal tallow melts at from 43° to 46° C. The amount of lard present was therefore comparatively small. The tallow was rancid, reacting acid with litmus paper.

A chemical examination of the burnt portion showed the presence of nitric acid. This would have resulted from the decomposition of the dye which contains much nitrogen. Nitric acid was also detected in other portions of the material *not* charred, showing that the dye had been decomposed partially by the rancid fat, but not to such an extent as where the burning occurred.

The dyeing was done in an alkaline bath (soda) to prevent this decomposition. The excess of this alkali is washed out and then the warp is sized. Rancid fat is acid and the acidity is increased by further oxidation of the fat, especially at the temperature named. This acid is liable to decompose the dye containing azo radicals liberating the oxides of nitrogen, which tend to increase the oxidation. Experimental proof of this was obtained. The warps being confined instead of cooling nurse the heat until the temperature rises to the charring point of cotton. These conditions being allowed to continue fire would result, as happened in this instance.

As stated above, while it is possible that gaseous compounds capable of burning cotton could come from the dye, it is probably not the case here. Certainly there is no danger if the tallow is fresh. The fire therefore may be attributed to the spontaneous combustion produced by the continued oxidation of rancid tallow. The fact that it was rancid was evidence that the oxidation had begun. Tallow that is only slightly rancid may be used with comparative safety when the process is rapidly carried out. The only absolutely safe plan however is to use fresh tallow. The rancidity of tallow shows itself by acid reaction to litmus paper.

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SOME DICHOTOMOUS SPECIES OF PANICUM.

[1] CONTRIBUTIONS FROM MY HERBARIUM. NO. VII.

W. W. ASHE.

PANICUM ALBEMARLENSE n. sp. A densely tufted perennial, dark green or purplish in color, 2–3 dm. high. Culms erect, strict, slender, villous with spreading or ascending 3–4 mm. long white hairs, leafy to near the top, barbed at the nodes: internodes much longer than the leaves and sheaths. Stem-leaves 3–5, firm, erect, 2–5 cm. long, 3–4 mm. wide, the longest near the middle of the stem, very gradually tapering to the apex from near the rounded base, pubescent above with long spreading white hairs, especially towards the base, mixed with shorter ones, pubescent beneath with short ascending hairs, the margins very rough and ciliate at the base with a few long hairs: ligule of a few 2 mm. long hairs; basal leaves 1–2 cm. long, 4–7 mm. wide, glabrate, at least when old. Primary panicle 2–4 cm. long, 1.5–3 cm. wide, the numerous branches ascending, on a short peduncle, 1–4 cm. long, or barely exserted: spikelets broadly obovate, 1.5 mm. long, 1.2 mm. wide, first scale acute, one-third the length of the strongly 7–9-nerved second and third scales, which are pubescent with spreading hairs.

PANICUM ALBEMARLENSE is very common in well drained open woods in Beaufort and Hyde counties, N. C., where the type material was collected by me May 26, 1899, near Scranton. It has the same habit and is closely related in character to *P. meridionale* Ashe, from which separated by being larger, having shorter pubescence, and larger spikelets.

I find that there has been previous use of a very similar name or of the same name which I have applied to the three following species of Panicum,[2] so I propose the following changes in their names:

PANICUM SHALLOTTE n. nom. *P. glabrissimum* Ashe, not *P. glaberrimum* Steud.

[1] Received Feb. 19, 1900.

[2] Jour. Elisha Mitch. Sci. Soc. 15, part 1, 1898.

PANICUM YADKINENSE n. nom. *P. maculatum* Ashe, not *P. maculatum* Aubl.

PANICUM BOGUEANUM n. nom. *P. annulum* Ashe, not *P. annulatum* A. Rich.

PANICUM AUSTRO-MONTANUM n. sp. A tufted perennial 1.5–2.5 dm. high. Culms very slender, erect, glabrous. Leaves of stem 2–4, spreading, .5–1.5 cm. long, 3–4 mm. wide, broadly lanceolate, narrowed or rounded at the base, light green, thin and soft; basal leaves numerous, somewhat longer than those of the stem: ligule a ring of hairs about 2 mm. long: sheaths very short, one-fourth to one-half the length of the internodes, generally about the length of the leaves, at least the lower pubescent, especially at the throat, with soft spreading hairs 2 mm. long, nodes barbed with soft spreading hairs. Panicle short-peduncled, 1–2 cm. long, and somewhat narrower, the branches spreading: spikelets broadly obovate, .7 mm. long, first scale one-third the length of the faintly 5–nerved glabrous second and third.

This species is related to *P. Cuthbertii* Ashe, from which separated by having pubescent sheaths and broader spikelets; and to *P. curtifolium* Nash, from which it is separated by having much shorter leaves and smaller spikelets. Along mountain streams of northern Alabama and the adjacent parts of Tennessee. Type material is preserved in my herbarium.

PANICUM CURTIVAGINUM n. sp. A tufted perennial. Culms glabrous, very slender, erect, 4–6 dm. high. Stem leaves 4–6, narrowly lanceolate, 4–8 cm. long, 3–5 mm. wide, the upper reduced in size, soft and thin, bright green, glabrous, except for a few 3–4 mm. long cilia at the base of the lower ones, faintly nerved, narrowed to the base, long taper-pointed, spreading or ascending; basal leaves somewhat longer and wider: internoded much longer than the leaves and sheaths, leaves longer than the sheaths: sheaths glabrous: ligule pubescent with white hairs about 1 mm. long. Panicle long-exserted, 3–6 cm. long, 2–3 cm. wide, the numerous branches ascending: spikelets broadly elliptic, quite 1.5 mm.

long, 1 mm. wide, abruptly acute, first scale 1–nerved, glabrous, one-fourth to one-third the length of the strongly 5–7–nerved thin glabrous second and third.

Collected at Petit Bois Island, Mississippi, May 8, 1898, by S. M. Tracy.

PANICUM WILMINGTONENSE n. sp. Perennial growing in small tufts. Culms very slender, erect, 3–4 dm. high, geniculate, pubescent, at least below, with short ascending hairs or above glabrate, at first simple, at length much branched: sheaths close-fitting, pubescent with short ascending hairs, one-half the length of the internodes or less: ligule a row of short white hairs about 1 mm. long. Stem leaves 3–4, shorter than the internodes, 3–6 cm. long, 3–5 mm. wide, broadest near the base, very long taper-pointed, slightly rounded at the base, glabrate or pubescent beneath with short ascending hairs or with a few long hairs on the margin near the base, thick and firm, the margins rough, white and thickened, upper leaves reduced in size: basal leaves equaling the lower stem leaves. Panicle ovate, 3–4 cm. wide, 5–7 cm. long, branches few, at least the lower ascending: spikelets broadly obovate, quite 2 mm. long, nearly glabrous, the 1–nerved first scale, about one-third the length of the glabrate 7–nerved second and third.

Panicum Wilmingtonense is closely related to *P. Atlanticum* but has smaller more acute spikelets, a more slender culm, scantier pubescence and smaller leaves. The type material collected in May, 1899 on the sand hills near Wilmington, N. C., is preserved in my herbarium.

PANICUM SUBVILLOSUM n. sp. A densely tufted perennial, 1.5–3 dm. high. Culms very slender, glabrous above, below pubescent with ascending hairs. Stem leaves 3–5, erect or ascending, lanceolate or narrower, 3–4 cm. long, 3–5 mm. wide, long taper-pointed, rounded at the base, nearly glabrous beneath, above pubescent with long white ascending hairs, margins rough, ciliate, at least near the base with long white hairs, upper stem leaves and basal leaves reduced in size: ligule pubescent with white hairs 2 mm. long: sheaths

pubescent with spreading hairs, much shorter than the internodes. Panicle on a long peduncle, 6–12 cm. long, broadly oval, 2–3 cm. long, 1.5–2.5 cm. wide, branches glabrous, spreading: spikelets broadly obovate, 1.5 mm. long glabrous, the obtuse first scale one third the length of the firm 7-nerved second and third.

Collected by the writer at Carlton, Minnesota, in August, in the simple state. Type material preserved in my herbarium.

Panicum parvipaniculatum n. sp. A densely tufted perennial, perfectly glabrous except the ligule. Culms 2–3.5 dm. high, erect, at length sparingly fasciculately branched and more or less reclining. Stem leaves 3–5, distant, spreading or the upper erect, very much shorter than the sheaths, one-fifth to one-third the length of the internodes, 1–2 cm. long, 2–3 mm. wide, lanceolate, the upper reduced in size, soft, but rough on the upper surface: ligule densely pubescent with hairs about 2 mm. long: basal leaves numerous, tufted, remaining green until after flowering, 2–4 cm. long, 4–5 mm. wide. Panicle exserted on a peduncle 3–5 cm. long, small, broadly ovate, 2–3 cm. long, 1.7–2.5 cm. wide, branches few, horizontal or at length strongly reflexed, spikelets elliptic, acute at both ends, glabrous, barely 1 mm. long, pedicels divaricate, first scale ovate, acute, scarcely one-fourth as long as the thin faintly 7-nerved second and third.

Panicum parvipaniculatum is related to *P. lucidum* from which it is separated by having somewhat smaller spikelets, smaller leaves and glabrous sheaths, and an erect habit. It begins to flower about two weeks earlier than *C. lucidum*. Collected May 20, in Onslow county, N. C. Type material is preserved in my herbarium.

Panicum pauciciliatum n. sp. A perennial forming small or large tufts. Culms 2–3 dm. long, rising from a geniculate base or reclining, at first simple at length much branched, reddish or purplish, slender, glabrous or the lower internodes puberulent. Stem leaves 3–4, lanceolate, 2–5 cm. long, 4–6 mm. wide, spreading or ascending: glabrous or with a few

stiff white cilia on the margin near the base : sheaths somewhat loose, often purplish, the lower less than one-half the length of the internodes : ligule none. Panicle 3–7 cm. long, broadly oval, the few branches spreading : spikelets 1.5 mm. long, obovate, obtuse, contracted at the base, the first scale very obtuse, nearly orbicular, about one-third the length of the nearly glabrous obtuse second and third.

This species is closely related to *P. demissum*, from which it is separated by having smaller and more numerous spikelets. Collected by me May 20, 1899, growing in dry sand near Wilmington, N. C.

Panicum Onslowense n. sp. A perennial growing in small tufts. Stems 2.5–3.5 cm. high, erect or rising from a geniculate base, glabrous. Stem leaves 3–5, 2–4 cm. long, 3–5 mm. wide, lanceolate, narrowed at the base, the upper reduced in size, erect or ascending, glabrous except a few short 2–3 mm. long cilia on the margin at the base, the edges white and roughened : basal leaves much longer and broader, sometimes 6 cm. long and 1 cm. wide : ligule none : sheaths glabrous, sheaths with the leaves shorter than the internodes. Panicle broadly ovate, 4–6 cm. long : branches few, fascicled, spreading very rough : peduncle 1–2 times the length of the panicle : spikelets very short-pedicled, elliptic, acute at both ends, 2–2.5 mm. long, the very thin obtuse first scale one-third to one-half the length of the strongly 7-nerved glabrous second and third.

Panicum Onslowense occurs in the flat woods and savannas near the coast in the southeastern part of North Carolina and the adjacent parts of South Carolina. It is not uncommon in the eastern part of Onslow county, N. C., where the type material was collected near Ward's Mill. It is related to *P. Nashianum* and *P. demissum*, from both of which it is separated by having acute spikelets and an erect habit.

Panicum filiramum n. sp. A perennial with 2–5 stems from the same root. Stems very slender, simple, ascending or spreading, at length much branched and reclining, 4–7 dm. long, pubescent at least below with short spreading or ascending hairs about 2 mm. long. Stem leaves 2–6 cm. long,

2–4 mm. wide, the upper very short, rather thin, narrowed at the base, ascending, pubescent especially on the lower surface and towards the base with spreading hairs, or glabrous: ligule villous with white hairs 3 mm. long: sheaths pubescent with spreading or ascending hairs 1–2 mm. long, especially at the throat: nodes barbed: basal leaves glabrate, much broader and shorter than the lower stem leaves. Panicle 4–6 dm. long, oval, the branches horizontal, glabrous: spikelets numerous, on very slender spreading pedicels, broadly obovate, 1.5 mm. long, first scale very obtuse, about one-third the length of the pubescent 5–7 nerved second and third.

This species is related to *P. arenicolum* and *P. arenicoloides*, but is separated from both by having very much smaller spikelets. Habitat: sandy woods, eastern North Carolina. Type material collected in New Hanover county, N. C., in June 1899.

Panicum arenicoloides n. sp. A perennial with 2–5 stems from the same root. Stems very slender, simple, ascending from a geniculate base, or at length much branched and spreading, 4–7 dm. long, pubescent, at least below, with 3–4 mm. long spreading white hairs, or merely puberulent, glabrate above. Stem leaves 5–8, spreading or ascending, 4–11 cm. long, 2–4 mm. wide, narrowed at the base, pubescent, especially near the base, with 3–4 mm. long spreading white hairs, or glabrate, the longest one-third above base of stem, upper much narrowed and shorter: basal leaves much broader and shorter: ligule of dense white hairs about 1 mm. long: sheaths one-third to one-half the length of the internodes, which are generally somewhat longer than the leaves, pubescent, especially the lower, or glabrate. Panicle 5–7 cm. long, 2–5 cm. wide, the rather few flexuous branches erect or ascending: spikelets obovate, 2–2.2 mm. long, abruptly acute, contracted at the base, first scale acute, one-third the length of the strongly 7-nerved very pubescent second and third: peduncle about the length of the panicle.

Habitat: shady sandy woods along the coast of North Carolina. Type material collected by me near Wilmington, N. C., June 6, 1899. This species is intermediate in many

ways between *P. arenicolum* and *P. neuranthum*. The very long narrow stem leaves and the pubescence of the plant are distinctive, however.

PANICUM ORTHOPHYLLUM n. sp. A somewhat tufted perennial. Stems strict, erect, glabrous, or pubescent with ascending hairs, 4–6 dm. high, primary stem leaves somewhat narrowed to the base, erect, glabrous or nearly so, 5–8 cm. long, 3–5 mm. wide: sheaths appressed pubescent or glabrous with a few cilia near the throat, shorter than the internodes, or the later crowded and overlapping: secondary leaves much narrower: ligule a ring of hairs 1–2 mm. long: basal leaves few, much shorter and broader. Panicle long-peduncled, ovate, the few branches erect, ascending or spreading, glabrous: spikelets barely 2 mm. long, broadly obovate, very obtuse, first scale small, obtuse, about one-fourth the length of the sparingly pubescent strongly 7-nerved second and third.

Shady slopes of sand hills, New Hanover county, N. C., June 1899. Related to *P. angustifolium* and *P. neuranthum*, from which separated by having smaller obovate spikelets.

PANICUM ERYTHROCARPON n. sp. A somewhat tufted perennial. Stem stout, erect, 4–6 dm. high, pubescent, at least below, with soft appressed or ascending hairs. Primary stem-leaves spreading or erect, 4–7 cm. long, 4–8 mm. wide, lanceolate, rounded or narrowed at the base, long taper-pointed, pubescent on both sides with appressed hairs, often mixed with long spreading hairs towards the base on the upper side, margins ciliate at the base: ligule pilose: sheaths appressed pubescent, often nearly as long as the internodes. Panicle 7–12 cm. long, 6–14 cm. wide, on a peduncle of about its length, the numerous fascicled branches spreading or drooping. Spikelets 2.5–3 mm. long, elliptic, acute, generally bright red, the first scale very acute, nearly one half as long as the pubescent 7-nerved second and third.

This plant is separated from *P. pubescens*, which it resembles, by having larger spikelets and ascending pubescence, and from *P. haemacarpon* by having larger spikelets, a more ample panicle, and much greater size.

The type material was collected by the writer on the sand hills of New Hanover county, N. C., May 19, 1899.

PANICUM MISSISSIPPIENSE n. sp. A tufted perennial 3–4 dm. high. Stems erect, glabrous or nearly so, often papillate below, at first simple, at length branched especially from the lower nodes. Primary stem leaves 3–7 cm. long, 3–7 mm. wide, rounded at the sparingly ciliate base, otherwise glabrous, rough on the margin: ligule a mere margin: sheaths much shorter than the internodes, papillate, glabrous except the edge which is finely ciliate with hairs 1–2 mm. long: basal leaves few and short, Panicle oblong, 3–5 cm. long, glabrous, on a peduncle 2–3 times its length, the mostly single branches short and horizontal: spikelets glabrous, nearly orbicular, 1.2 mm. long, 1 mm. wide, the nearly orbicular first scale, one-third the length of the very thin faintly 5-nerved, glabrous second and third: later panicles exserted on short peduncles.

A very distinct species. Collected by me on the banks of the Mississippi river below New Orleans in October. I also refer here S. M. Tracy's No. 6777, collected on Horne Island, Miss., in July 1899.

PANICUM TAXODIORUM n. sp. A very slender perennial, 4--7 dm. high, at first simple and erect, at length spreading and loosely branched. Leaves very thin, glabrous, dark green, the edges very rough, 4--10 long, 3--5 mm. wide, narrowly lanceolate, narrowed to the scarcely rounded base, long taper-pointed: ligule none: sheaths glabrous except the finely ciliate margins, or with a few long hairs at the throat: basal leaves, in the specimen at hand very short, and few. Panicle 6--10 cm. long, ovate, the branches few, slender, fascicled, ascending: spikelets full 2 mm, long, elliptic or obovate, acute, glabrous, short-pedicled.

This species is related to *P. dichotomum* but differs in the panicle having fewer, ascending branches, acuter spikelets, narrower leaves, and in having the secondary panicles exserted.

Type: K. K. McKenzie's No. 460. Hummocks in cypress swamps. Lake Charles, La., September 1890.

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